
**इस्पात कार्य एवं अन्य संस्थानों पर उपयोग
के लिए विशेष प्रयोजन के लिये क्रेन सहित
इलेक्ट्रिक शिरोपरि यात्रा क्रेन तथा
गैन्ट्री क्रेन — रीति संहिता**
(तीसरा पुनरीक्षण)

**Electric Overhead Travelling
Crane and Gantry Crane for all
Applications — Code of Practice**
(Third Revision)

ICS 53.020.20

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FOREWORD

This Indian Standard (Third Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Cranes Lifting Chains and its Related Equipment Sectional Committee had been approved by the Mechanical Engineering Division Council.

This standard was originally published in 1965 and subsequently revised in 1977 and 1999. In this revision all the amendments have been incorporated and the following major changes have been made:

- a) To help standardization, as far as possible, relating requirements for components to basic duty factor for class of mechanisms.
- b) Recommended selection of group mechanism (duty class) of the crane for purchaser.
- c) Simplified graphical method for calculating permissible fatigue stress.
- d) Selection of wheel and giving due consideration of duty class, travel speed and wheel material.
- e) Selection of sizes for wire rope, rope drum, sheave and allowable fleet angle using graphical method.
- f) Provision of compacted rope, seamless pipe for rope drum, case carburized gearboxes, geared brake motor, etc. have been made.
- g) Motor selection with thermal adequacy, use of service factor and RMS method has been prescribed.
- h) The mechanism duty is classified in eight groups M1 to M8 based on their total duration of utilization applying upto the time of replacement of mechanism and load spectrum that is, life load cycle.
- j) Certain other changes for better implementation of the standard.

The requirements of IS 4137 : 2015 'Heavy duty electric overhead travelling cranes including special service machines for use in steel work — Code of practice' has been covered in this revision. This Indian Standard supersedes the IS 4137 : 2015.

This standard covers design, manufacture and erection of electric overhead traveling cranes and gantry cranes for use in steel works and other locations. The standard also covers mechanical, electrical, inspection and testing aspects as related to design, manufacture and erection of electric overhead traveling cranes in order to secure safe, efficient and reliable working of these heavy duty cranes during service. Structural design aspects of all types of cranes and hoists are covered in IS 807 : 2006 'Design, erection and testing (structural portion) of cranes and hoists — Code of practice. Cranes are broadly classified into eight classes in IS 807 depending on duty and number of hours in service per year.

The new classification of cranes now coming into effect and the classification presently in use can approximately be compared as follows:

Old Equivalent	New Classification	Average Working Hours Per Day	Average Total Life in Working Hours, Min
I	M1	0.5-4	400
	M2		800
	M3		1 600
II	M4	4-6	3 200
	M5		6 300
III	M6	6-9	25 000
IV	M7	6-9	35 000
	M8	12	75 000

NOTE — The running time per day and total life relate to mechanism class only.

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Indian Standard

ELECTRIC OVERHEAD TRAVELLING CRANE AND GANTRY CRANE FOR ALL APPLICATIONS — CODE OF PRACTICE

(*Third Revision*)

SECTION 1 GENERAL

1 SCOPE

1.1 This standard covers requirements for design, manufacture, inspection and testing of electric overhead travelling cranes and gantry cranes for use in steel works and other locations. Its provisions where applicable, shall also apply to special purpose cranes, such as, those listed in Annex A including steel plant crane and other overhead travelling cranes, portal and semi-portal cranes, single girder, double girder or mono-box type (Fig. 1). It is recommended that, the crane should be designed based on the duty classes and application, irrespective of usage in steel works or at other locations. Classification of the crane as a whole shall be taken as defined from classes A1, A2, ... A8 and as defined as from mechanism classes M1, M2, ... M8 classification as defined in foreword. Structural design aspects of all types of cranes and hoists are covered in IS 807.

1.2 The duty class of crane preferably be selected as per **1.1**.

1.3 Annex B gives guidance which may be referred by purchaser while specifying the duty class.

1.4 This standard is not intended for application to cranes for use in areas where sparks from cranes could lead to explosions.

1.5 It is recommended that IS 13367 (Part 1) to be referred for safe usage of crane.

1.6 Risk assessment and risk reduction to be carried out as per IS 16819 and IS 16504 (Part 1) if agreed between the manufacturer and the purchaser.

2 REFERENCES

The standards listed in Annex C contain provisions, which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the

possibility of applying the most recent editions of the standards indicated in Annex C.

3 TERMINOLOGY

3.1 General — For the purpose of this standard the definitions given in IS 13473 (Part 1) and following text shall apply. If there are common terms, the definitions given in this standard shall prevail.

3.2 Normal Service Condition — Normal service condition shall satisfy the following conditions:

- a) Indoor and outdoor applications should with normal air of normal humidity and free from contamination;
- b) Ambient temperature should be 0°C to 40°C and if the service conditions those beyond this, suitable derating factors shall be applied; and
- c) Altitude should not exceed 1 000 m above mean sea level.

4 TECHNICAL INFORMATION TO BE PROVIDED

4.1 Information to be Supplied with Enquiry or Order

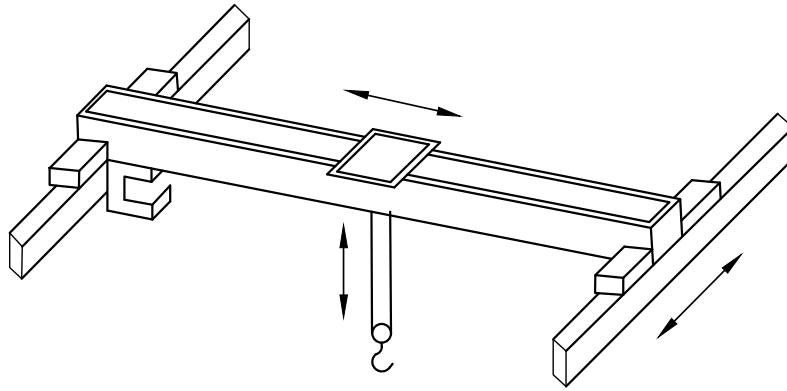
Information regarding the conditions under which the crane is to be used, together with the information required in Annex D, shall be supplied with the enquiry or order.

4.2 Information to be Supplied by the Manufacturer with Offer

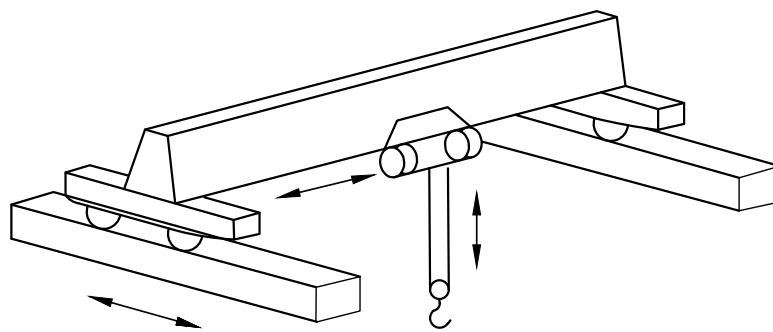
The manufacturer shall supply all technical details/ documents together with the information required in Annex E including drawings giving the over all sizes, clearance, end approaches, structural features, travel wheel loads, type of buffers, impact forces, wheel spacing, etc.

5 IDENTIFICATION

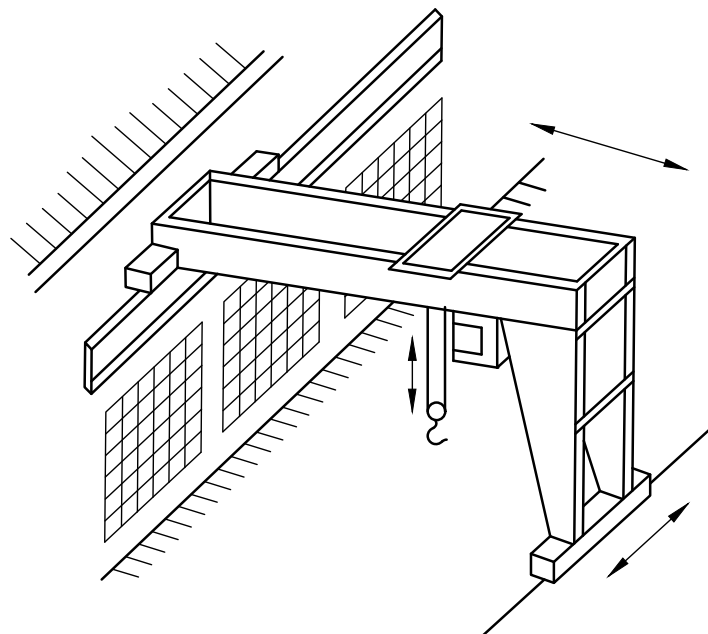
5.1 A small plate shall be located in a prominent position in the cabin or suitable location bearing the



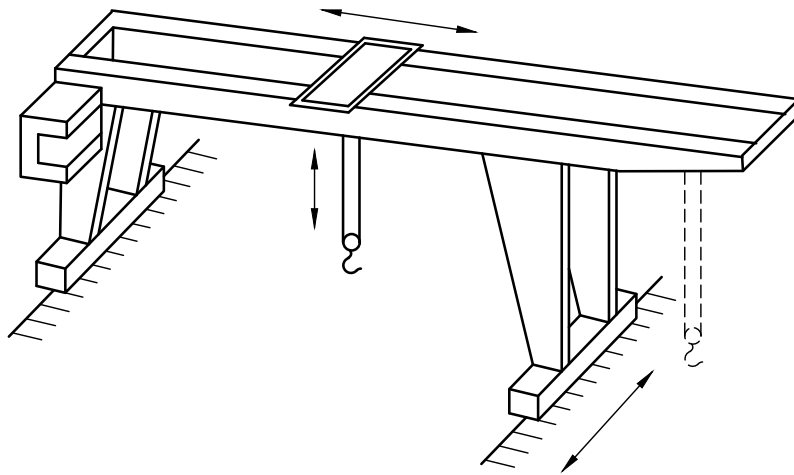
1A TOP RUNNING CRANE (DOUBLE GIRDER)



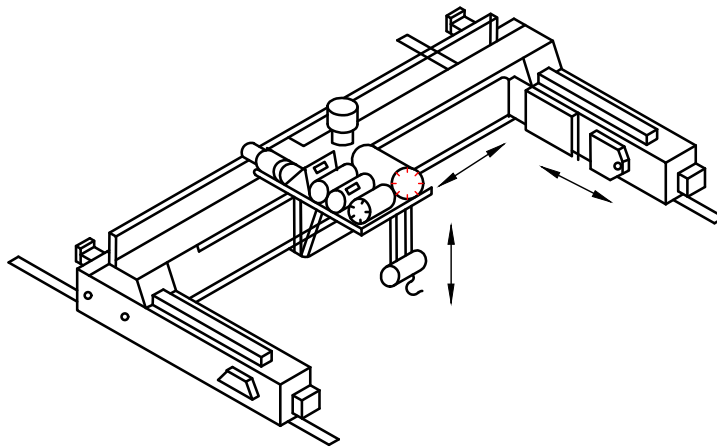
1B TOP RUNNING CRANE (SINGLE GIRDER)



1C SEMI GOLIATH (GANTRY) CRANE



1D GOLIATH (GANTRY) CRANE (WITH CANTILEVERED EXTENSION)



1E OFFSET CRAB CRANE

Notes

- 1 The classification given in foreword is for guidance only. However, while correlating between earlier classifications and proposed M1 to M8, the new classification shall prevail with clear understanding of customer requirements, keeping in view the interests as protected by the earlier classification.
- 2 The classification of the individual motions of a crane may not necessarily be the same as those of crane structure. The classification of one motion of a crane may differ from the another motion of the same crane.
- 3 In the case, where a crane mechanism is required to perform a duty that falls beyond the group classification M8, either the mechanism shall be designed for higher hook load or other parameters shall be charged so that it satisfies requirement for the group classification M8.

FIG. 1 TYPICAL CRANE TYPES

following inscription:

- a) Manufacturer's name;
- b) Manufacturer's serial number;
- c) Year of manufacture;
- d) Safe working load; and
- e) Nomenclature of crane.

5.1.1 In general purpose cranes, X/Y indicates the following:

- a) X — Capacity of the main hook, in tonnes; and
- b) Y — Capacity of the auxiliary hook, in tonnes.

Both the hoists are mounted on one trolley (double girder).

5.1.2 X + Y indicates the following:

- a) X — Capacity of the main hoist in tonnes; and
- b) Y — Capacity of the main auxiliary hoist, in tonnes.

Main hoist is mounted on main trolley and the auxiliary hoist on a separate auxiliary trolley and both the trolleys may be on same girder (double girder) or on different girders (four girders).

5.1.3 X/Y/Z indicates the following:

- a) X — Capacity of the main hoist, in tonnes;
- b) Y — Capacity of the auxiliary hook 1; and
- c) Z — Capacity of the auxiliary hook 2.

All hooks are mounted on one trolley (double girder).

5.1.4 X + Y / Z indicates the following:

- a) X — Capacity of the main hoist, in tonnes;
- b) Y — Capacity of the main hook of the auxiliary trolley; and
- c) Z — Capacity of the auxiliary hook of the auxiliary trolley.

Main hoist hooks are mounted on one trolley and both the hooks of auxiliary trolley are mounted on another trolley and both the trolleys may be on same girder (double girder) or on different girders (four girders for ladle cranes).

5.2 Rating Plate

- a) The lifting capacity shall be permanently marked in a visible position and shall be easily legible from the ground;
- b) In case of grabbing cranes, the lifting capacity shall be permissible total weight of the grab and the lifting capacity; and
- c) In the case of cranes with more than one hoist, the lifting capacity of each hoist shall be indicated on the relevant hook block.

5.3 Manufacturer's Name Plate

The manufacturer's name plate shall contain the following details:

- a) Name of manufacture;
- b) Year of manufacture;
- c) Manufacturer serial number; and
- d) Safe working load of each hoist shall be permanently marked on each side of crane in such a manner as to be easily legible from the floor and in tonnes;

5.4 Warning Notices

The following warning notices shall be suitably located so as to be clearly visible:

- a) Do not stand under the load;
- b) No access for unauthorized personnel; and
- c) Danger-crane; by means of warning colour strips (as applicable).

6 WORKMANSHIP, MATERIAL AND INSPECTION

6.1 Workmanship and material shall be subject to the inspection of the owner or his representative at all times. Weldments of carbon steel (except bridge girder, trolley structure, boggie, end carriage) shall be stress relieved by uniformly heating in a furnace, wherever applicable. Field welds shall likewise be stress relieved unless other means agreeable to the owner as specified in the information sheet. The temperature of the furnace when the weldment is placed in it shall not be over 150°C at the start and increased to 650°C at a rate not exceeding 95°C/h, and then held at the temperature for 1 h/25 mm of thickness of material. It shall then be cooled in the furnace at a rate (not exceeding 95°C/h) to 260°C, before being removed from the furnace. Weldments of alloy material shall be welded and stress relieved using a procedure as per IS 16003 or ASME, Sec - IX.

6.2 The stress relieving shall be applicable for the plate thickness of more than 40 mm as per AWS 14.1 or ASME Section VIII, Div I. For larger components where the thermal stress relieving is not possible, as an alternative, the mechanical vibratory method shall be applied. To stress relieve the field weld, local flame heating shall be applied.

6.3 Safety Clearances

All moving parts of the cranes shall be at least 100 mm from any fixed part of a building/structure and minimum of 600 mm from human access area. Alternatively, the safety clearances shall be as per agreement between the purchaser and the manufacturer.

SECTION 2 MECHANICAL COMPONENTS

7 DESIGN PROCEDURE

7.1 General

The design of the component parts of the mechanism relating to each crane motion shall be included with due allowance for the effects of the duty which the mechanism shall perform in service. The design of the component parts will be in accordance with the provisions given in this section.

7.2 Load Amplifying Factor

The load amplifying factor applied to the motion of the hook in a vertical direction covers inertia forces including shock. In calculating fatigue analysis in the components of the mechanism the live loads, the rated hook load shall be multiplied by the load amplifying factor, given in Table 1.

NOTE — Load amplifying factor for structural design shall be as per IS 807. Table 1 refers for fatigue design of mechanical components only.

**Table 1 Factor for Mechanical Design
(for Fatigue Analysis)**

(Clauses 7.2 and 7.4.3.2)

Sl No.	Group Classification of the Mechanism	Load Amplifying Factor
1)	(2)	(3)
i)	M1	1.00
ii)	M2	1.04
iii)	M3	1.08
iv)	M4	1.12
v)	M5	1.16
vi)	M6	1.20
vii)	M7	1.25
viii)	M8	1.30

7.3 Loadings to be Considered in the Design of Mechanisms

7.3.1 Loads

The following loadings shall be taken into account when designing a mechanism and its components:

R_d = Loads due to the dead weight of the mechanism or component and dead weight of those parts of the crane acting on the mechanism or the component under consideration.

R_h = Loads due to the weight of the hook load with reference to Fig. 2 and also it is defined as SWL of the hook.

R_{hi} = Loads due to the weight of the hook load increased by the load amplifying factor given in 7.2.

R_m = Dynamic loading arising from the acceleration or braking of the motion and from skewing interaction between the crane and track. These loads include those loads due to the following reasons:

- inertia of the mechanism, associated crane parts and hook load;
- its prime mover and brakes; and
- concurrent operation of other motions, etc, as applicable.

R_f = Loads arising from frictional forces.

R_{w1} = Loads due to the service wind acting horizontally in any direction where applicable according to IS 807.

R_{w2} = Loads arising out of wind pressure during out of service condition with wind acting horizontally in any direction where applicable according to IS 875 (Part 3).

R_c = Loads due to collision with end buffers.

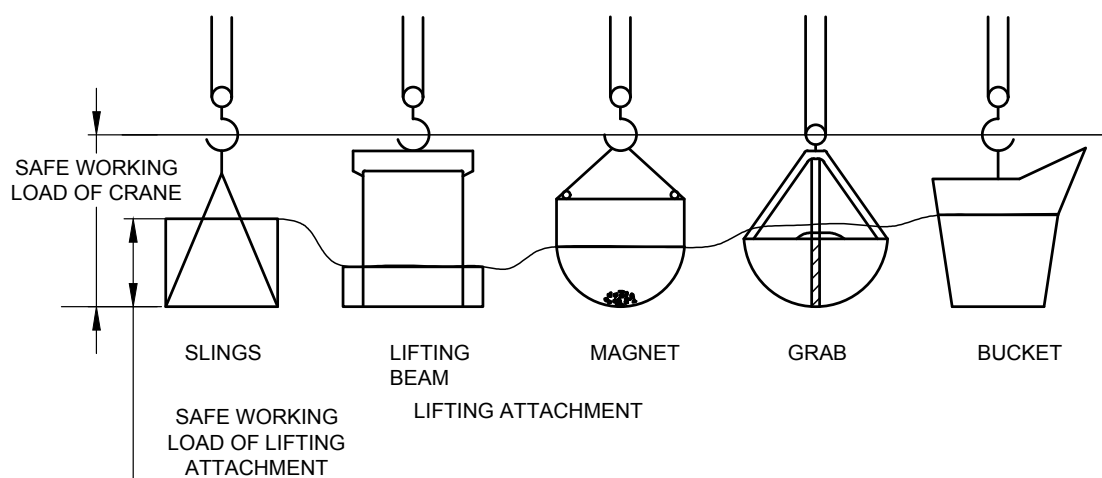


FIG. 2 ILLUSTRATION OF TYPICAL ATTACHMENTS IN RELATION TO SAFE WORKING LOAD

7.3.2 Loading Condition and Load Combinations

Each mechanism of the crane shall be designed to operate satisfactorily under the most unfavourable combination of loadings that can occur under different conditions and that could also actually occur in practice.

7.3.2.1 Case I - Normal service without wind where crane capacity equal to R_h

a) *Vertical Motion* — Hoisting or lowering:

- 1) $R_d + R_h + R_m + R_f$; or
- 2) $R_d + R_{hi}$

b) *Horizontal Motion* — Traverse or travel:

$$R_d + R_h + R_m + R_f$$

7.3.2.2 Case II - Normal service with wind

a) *Vertical Motion* — Hoisting or lowering:

- 1) $R_d + R_h + R_m + R_f + R_{w1}$; or
- 2) $R_d + R_{hi} + R_{w1}$.

b) *Horizontal Motion* — Traverse or travel:

$$R_d + R_h + R_m + R_f + R_{w1}$$

7.3.2.3 Case III Crane out of service

a) *Vertical Motion* — Hoisting or lowering not applicable.

b) *Horizontal Motion* — Traverse or travel :

$$R_d + R_{w2}$$

7.3.2.4 Case IV — Exceptional loading condition

The combination of loads to be considered for this case of loading will depend upon the type of crane, application and the crane motion. Account shall be taken of any loading condition that are known to apply but which are not covered under the other three cases of loading. A few cases of exceptional loading are as follows:

- a) Loads due to collision of cranes with each other or with end stoppers that is buffer loads;
- b) Loads due to testing of cranes;
- c) Erection loads; and
- d) Loads due to the maximum load that the motor can actually transmit to the mechanism while starting, stalling or due to higher actual power.

7.4 Design Procedure

7.4.1 General

Mechanism components shall be proportioned by checking that they have adequate safety against becoming unserviceable as a result of a single combination of extreme loading conditions causing fracture, bending or other type of failures. They shall also be checked whenever appropriate against fatigue, deflection or over heating. In this connection,

consideration shall be given to the consequences of failure. For example, failure in hoisting mechanism component is usually more dangerous occurrences than failure of a horizontal motion mechanism.

7.4.2 Basis of Design

Mechanism components are checked depending on the ultimate strength by verifying that the calculated stress does not exceed a permissible stress dependent on the breaking strength of the material used.

NOTE — If, C_{df} is considered in calculation of allowable strength then load amplifying factor as mentioned in 7.2 need not to be considered.

7.4.3 Permissible Stress

Mechanism component shall be checked for strength under case I, II, III and IV loading conditions and load combinations specified in 7.3.2. The value of the permissible stress F_a is given by following formula where unit of stress was defined as N/mm²:

$$F_a = \frac{F_{ult}}{C_{df} \times C_{bf} \times C_{sf}}$$

Where,

F_{ult} = ultimate tensile strength of the material;

C_{df} = duty factor for the appropriate mechanism class. For the values see Table 2;

C_{bf} = basic stress factor corresponding to each case of loading. For the values see Table 3; and

C_{sf} = safety factor depending on the material used. For the values see Table 4.

7.4.3.1 Permissible stress F_a should be reduced by 20 percent in the crane component for reverse bending.

7.4.3.2 Normally, the steel plant cranes are designed for M6, M7 and M8 class duty which need to be checked against fatigue / endurance limit. The working stress is to be calculated based on below formula,

Working stress = Stress due to rated load $\times$ stress concentration factor $\times$ load amplifying factor.

That is, for bending:

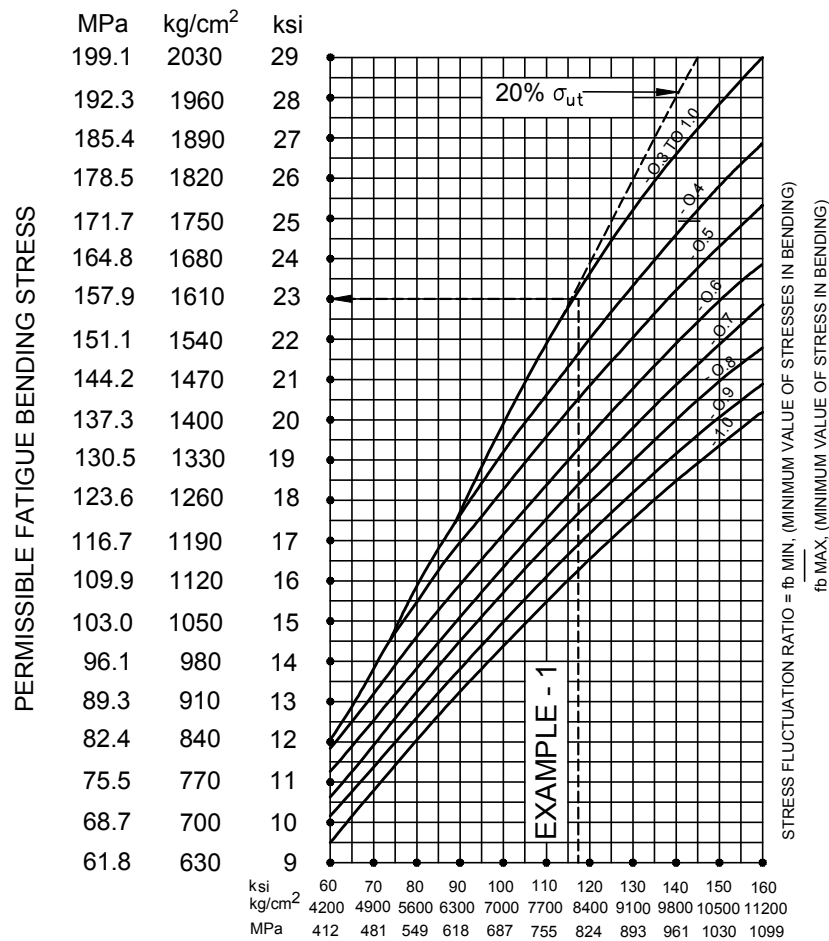
$$f_{b\text{Max}} = f_{bc} \times K \times \text{Load amplifying factor (as per Table 1)}$$

Where,

K = Stress concentration factor.

As load amplification factor has been considered C_{df} is not being consider.

The permissible fatigue stresses in bending P_{fb} is obtained from Fig. 3, permissible fatigue stresses in tensile P_{ft} is obtained Fig. 4 and for permissible fatigue stress in shear P_{fs} obtained from Fig. 5 based on the ultimate strength of the selected material.



MINIMUM ULTIMATE TENSILE STRENGTH AT MID RADIUS

Example shown in above figure indicates that, the material with 117 ksi minimum UTS have maximum allowable bending stress 16.1 ksi for stress fluctuation ratio -1.0 and 23 ksi for stress fluctuation ratio -0.3 and 1.0. For determining stress fluctuation ratio, it should be observed that the stress having the maximum absolute magnitude (regardless of whether it is a tension, compression, shear, combined or equivalent stress) is to be considered positive in all cases. The minimum stress is to be considered positive if it is of the same sense as the maximum stress, otherwise it is to be taken as negative. Referring Fig. 3 to Fig. 5, in regions of combined stress $f_{a \text{ Max.}}$ or $f_{b \text{ Max.}}$ or $f_{s \text{ Max.}}$ should be taken as the maximum combined or equivalent stress having the maximum absolute magnitude. $f_{a \text{ Min.}}$ or $f_{b \text{ Min.}}$ or $f_{s \text{ Min.}}$ shall be taken as the absolute minimum stresses which do occur at the same location as the maximum stress.

FIG. 3 PERMISSIBLE FATIGUE BENDING STRESS, P_{bc}

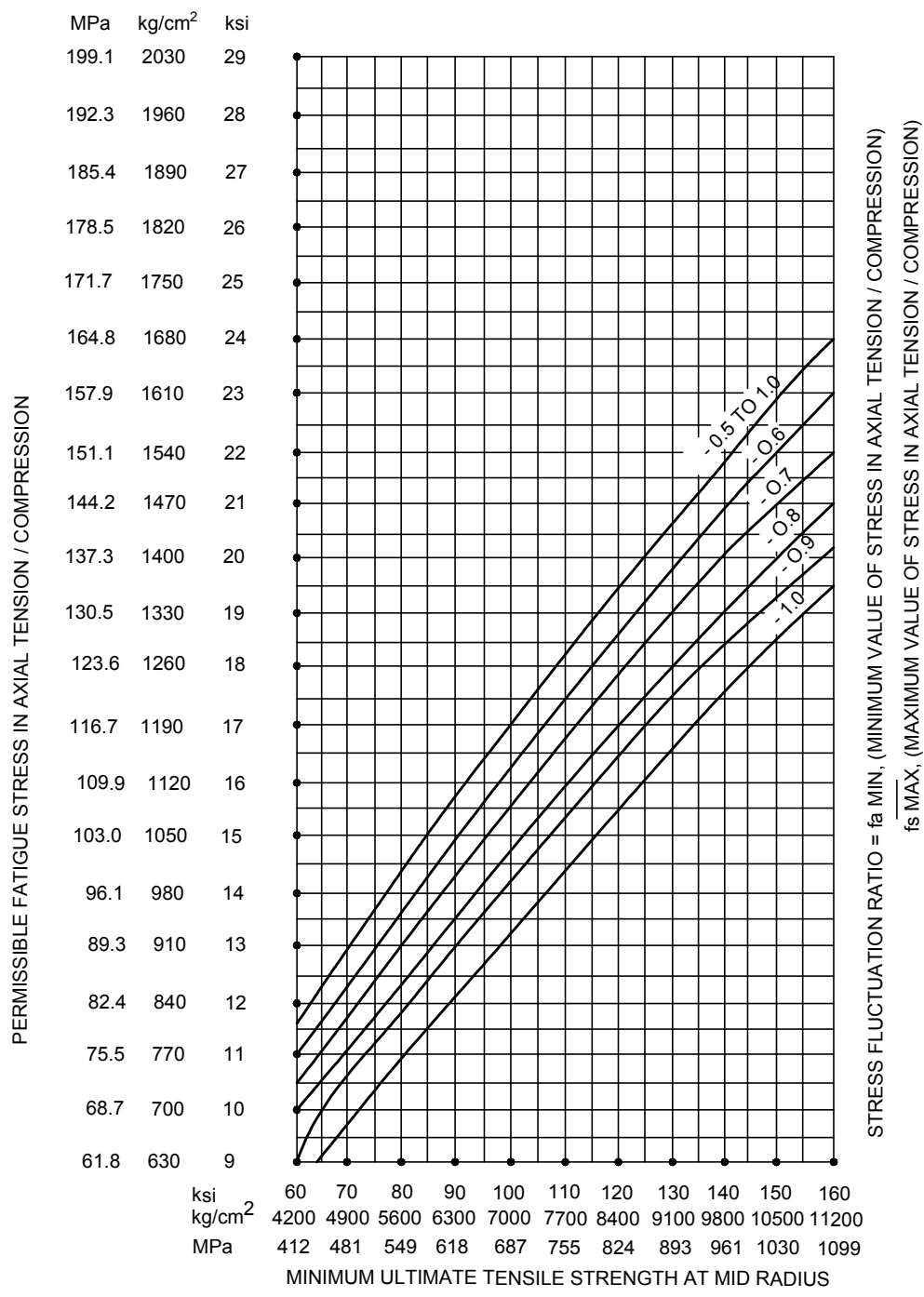
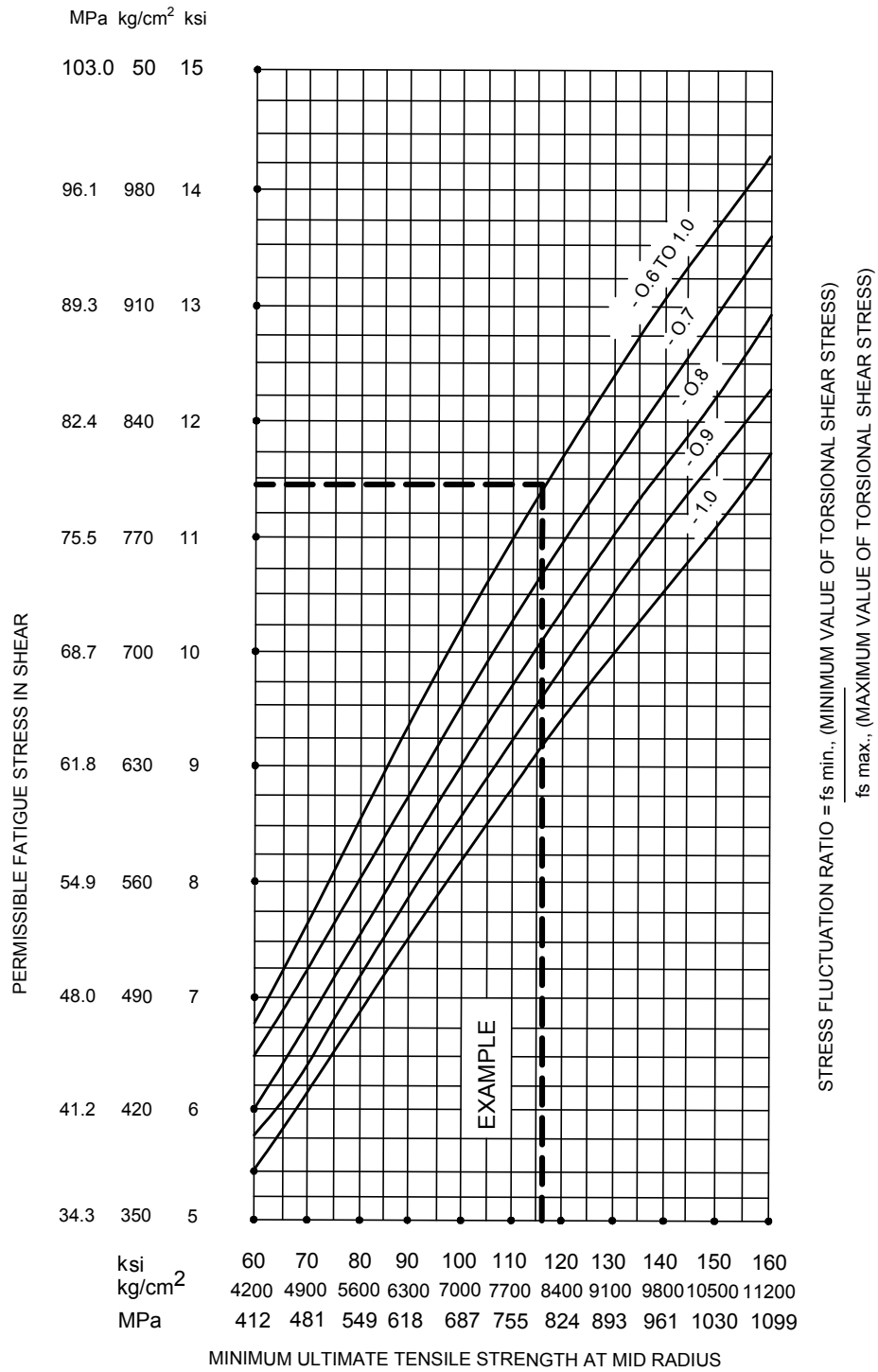


FIG. 4 PERMISSIBLE FATIGUE STRESS IN AXIAL / TENSION, P_{fa}

FIG. 5 PERMISSIBLE FATIGUE STRESS, P_{fs}

The allowable stress coming from Fig. 3 to Fig. 5 is to be compared with F_a value as per 7.4.3.1 and the lower value should be considered in the calculations.

7.4.3.2.1 Alternatively value of permissible fatigue stress P_{fr} (P_{fb} and P_{fs}) can also be calculated as per Annex F.

7.4.3.3 The static bearing stress in any part of a crane component, calculated on the net area of contact shall not exceed the value of determined by the following formula:

$$\sigma_p = 0.75 f_y$$

where,

σ_p = Maximum permissible static bearing stress;
and

f_y = Yield stress of selected material.

7.4.4 Relation between Calculated and Permissible Stresses

According to the type of loading to be considered the following relations shall be verified:

- Pure tension $1.25 f_t \leq F_a$
- Pure compression $f_c \leq F_a$
- Pure bending either compression or tension

$$f_{bt} \text{ or } f_{bc} \leq F_a$$

- Combined bending and tension

$$1.25 f_t + f_{bt} \leq F_a$$

- Combined bending and compression

$$f_c + f_{bc} \leq F_a$$

- Pure shear

$$\sqrt{3} f_s \leq F_a$$

- Combined bending, tension and shear

$$\sqrt{[(1.25 f_t + f_{bt})^2 + 3 f_s^2]} \leq F_a$$

- Combined bending, compression and shear

$$\sqrt{[(f_c + f_{bc})^2 + 3 f_s^2]} \leq F_a$$

Where,

f_t = calculated axial tensile stress,

f_c = calculated axial compressive stress,

f_{bt} = calculated maximum tensile stress due to bending about both principal axes,

f_{bc} = calculated maximum compressive stress due to bending about both principal axes, and

f_s = calculated shear stress.

7.4.5 Checking for Fatigue

7.4.5.1 General

Where it is necessary to check a component for fatigue, recognized techniques available for calculation of fatigue properties shall be used. The choice of the methods used shall be left to the manufacturer, however, he shall specify the origin of the methods to be adopted, if asked by the customer.

Table 2 Values of Co-efficient, C_{df}

(Clauses 7.4.3 and 7.4.5.6)

Sl No.	Group Classification of Mechanism	For Mechanism used for Horizontal Motion	For Mechanism Used for Vertical Motion	For Mechanism Used for Vertical Motion or While Handling Dangerous Material for Example, Molten Metals, Highly Radioactive or Corrosive Products
(1)	(2)	(3)	(4)	(5)
i)	M1	1.00	1.18	1.32
ii)	M2	1.06	1.25	1.40
iii)	M3	1.12	1.32	1.50
iv)	M4	1.18	1.40	1.60
v)	M5	1.25	1.50	1.70
vi)	M6	1.32	1.60	1.80
vii)	M7	1.40	1.60	1.90
viii)	M8	1.50	1.70	2.00

Table 3 Values of Coefficient, C_{bf}

(Clause 7.4.3)

Case of Loading	I	II	III and IV
C_{bf}	3.15	2.5	2.0

Table 4 Values of Coefficient, C_{sf}
(Clause 7.4.3)

Sl No. (1)	Safety Factor Depending on the Material Used (2)	Values of Coefficient (3)
i)	For ordinary grey cast iron or for cast or forged components where blow holes or internal cracks can not be detected.	1.25
ii)	For mild steel $E 250$, $E 350$ and $E 410$	1.12
iii)	For heat treated and tested material (for example, 42CrM04, C45, C55Mn75)	1.00

7.4.5.2 Loading condition

Case I of loading condition as specified in 7.3.2 shall be used as the basis for all fatigue checks.

7.4.5.3 Factors affecting fatigue strength

For any component, the magnitude of the permissible fatigue stress (p_f) depends upon the following factors:

- Total number of stress cycles during the service life of the component 'n';
- Type of stress cycles (that is, degree of stress fluctuation);
- Quality of the material;
- Size of the component;
- Surface finish of the component;
- Configuration of the individual details under consideration; and
- Miscellaneous effects such as the effects of corrosion, residual stress, electrolytic plating, metal spraying, etc, where under certain conditions reduce the permissible fatigue stress. 7.4.5.4 gives a method for calculating the fatigue reference stress (p_{fr}) which takes account from the factor (a) to (g).

NOTE — A check for fatigue need not be made in the cases, where experience shows that the ultimate strength check as per 7.4.3 is sufficient.

7.4.5.4 Stresses

The following characteristics shall be determined for each type of fluctuating stress, for example, tension, compression, bending or shear, occurring during an appropriate stress cycle in the component detail having regard to the loading that it will experience:

- f_{Max}, f_{Min} = Extreme values of stress occurring in the stress cycle;
- f_{Min} = Considered as negative if it is of opposite sense to f_{Max} ;
- p_{fb} = Permissible fatigue stress, in bending;
- p_{fs} = Permissible fatigue stress, in shear;
- p_{fr} = Fatigue reference stress at which a component detail has a 90 percent probability of survival;

- P_{fa} = Permissible fatigue, in axial tension;
- $f_{a Max}, f_{a Min}$ = Extreme values of axial tensile stress;
- $f_{b Max}, f_{b Min}$ = Extreme values of stress, in bending;
- $f_{s Max}, f_{s Min}$ = Extreme values of torsional shear stress; and
- f_{Min}/f_{Max} = Maximum degree of stress fluctuation.

7.4.5.5 Permissible fatigue stress

When single nature of stresses are applicable, then the working stress should be less than permissible fatigue stress which is to be calculated as per 7.4.3.2 .

The stress combination occurring most frequently in practice in a component detail is that of bending and torsion. The details subjected to this combination shall be designed so that:

$$(f_{b Max}/P_{fb})^2 + (f_{s Max}/P_{fs})^2 < 1.0$$

7.4.5.6 Checking for crippling

Component subjected to crippling that is overall flexural buckling due to axial compression shall be checked so that the calculated stress does not exceed a limit stress determined as a function of critical stress above which there is a risk of crippling occurring. For this check coefficient C_{dr} as given in Table 2 shall be taken into account.

7.4.5.7 Checking for wear

In the case of parts subjected to wear, the specific physical quantities, such as, surface pressure or the circumferential velocity must be determined. The figures must be such that on the basis of OEM/ international practices they will not lead to excessive wear.

7.4.5.8 Means of access

7.4.5.8.1 General requirements

In front of the panel the working place shall be minimum of 500 mm or width of the door of the panel or whichever is more. Safe means of access shall be provided to the driver's cabin and to every place where any person engaged on the inspection, repair and

lubrication of the crane will be called upon to work, adequate handholds and footholds being provided where necessary.

7.4.5.8.2 Platforms

Every platform shall be securely fenced with double tiered guard rails having a minimum height of 1.1 m and toe boards, unless parts of the crane structure provided safely. The platform normal width with only chequered plates shall be of sufficient to enable normal maintenance work to be carried out safely. On bridge platform, minimum clear width which shall be not less than 0.50 m in normal width, the fencing shall extend along the full length of the outer edge. Guard rails on the trolley side of the bridge platform may be provided, if required.

7.4.5.8.3 Ladders

Sides of ladders shall extend about 1 m above top rung, unless some other appropriate handhold is provided. Ladders shall if possible, slope forward. Vertical ladders exceeding 3 m in length shall be provided with back safety guards. The ladders over 5 m in height should be provided with safety hoops starting at a height of 2.5 m. The distance between safety hoops shall not be greater than 0.9 m. The strength of safety hoops must be adequate to withstand a force of 100 kg distributed over 100 mm acting on any point of the loop. The ladders must be provided with rest platforms spaced so that the first stretch does not exceed 10 m and there are then rest platforms at every 8 m.

7.4.5.8.4 Stair ways

Slope of stairways should preferably be 45°, however shall not exceed 60° (with horizontal), the height of individual steps shall not exceed 250 mm and their depth shall not be less than 150 mm the surface of treads shall be anti-slip. The stair ways shall be provided with guard rails on each side.

NOTE — In case of space constraint, slope of stairways may be mutually decided by the purchaser and the manufacturer.

8 HOOKS

8.1 The hook material and rated capacity shall be selected from IS 15560, IS 5749, and DIN 15407-1 or AISE 7 (for Laminated hooks). DIN 15400 for single point and Ramshorn hooks are also acceptable. Radiography test may be done for forged hook, if mutually agreed between the purchaser and the manufacturer.

8.2 General

Hooks shall be designed for the rated load. The design shall be established by analysis or testing as per relevant standards.

8.3 Details

Hooks shall be forged from fine grained material. Any welding on the hook shall be with the approval

of qualified welding engineer and performed prior to initial heat treatment. The capacity of hook may be stamped on the hook nose. The hook shall not be painted.

8.4 Hook Body

Hook bodies shall be of standard design where the line of resultant load on the hook passes through the centre of curvature of the inside edge of the hook and coincides with the centerline of the shank.

8.5 Testing

A certificate of compliance showing static load testing (proof load test) covering the configuration of the hook body and the hook shank shall be provided.

8.6 Latches

Hook latches and swivel lock plates shall be provided when specified.

8.7 Mounting

Swiveling hooks shall be mounted on thrust bearings. A protective skirt shall be provided to enclose the bearings. The thrust bearings shall be provided with facilities for lubrication.

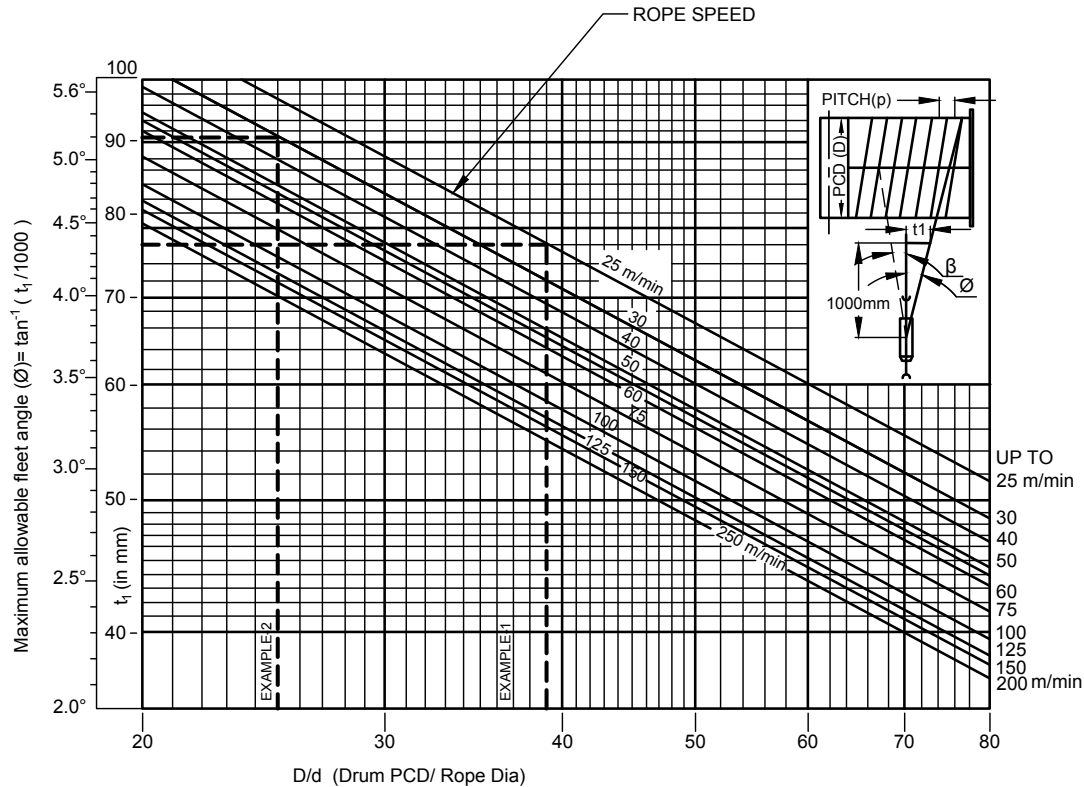
9 WIRE ROPES

9.1 The hoisting ropes shall be of the grade and type specified in IS 2266. Steel cored ropes shall be used for cranes handling hot metal or where the rope has to be used under water or in corrosive atmosphere. All wire ropes shall generally be of ordinary lay, right hand, pre-formed and ungalvanized. For grab cranes one rope may have left hand lay and the other right hand lay or non-rotating rope according to IS 2266. The compacted ropes suitable for crane duty may be used as per agreement between the purchaser and the supplier based on various crane's application. Ropes working under water and in corrosive atmosphere shall be galvanized. Reverse bend in the rope reeving shall be avoided as far as possible. The sheave arrangement should be reeved so as to eliminate reverse bends preferably except at the drum and equilizer.

9.2 The maximum allowable fleet angle for frequent working positions shall be 3° for all classes of cranes. However, maximum allowable fleet angle for seldom reach position may be permitted upto 5°. Fig 6 may be referred for further guidance with respect to rope speed.

The negative fleet angle can be calculated based on below formula: Negative fleet angle = Allowable positive fleet angle $-\tan^{-1}$ (Pitch of the groove / $3.14 \times$ rope PCD on the drum)

When special reeving, such as, a stabilized reeving arrangement is used, consideration must be given to geometry and dynamics to maintain the appropriate safety factors. Provisions should be made to prevent the twisting of the hook block.

**Example 1 : Input data**

Crane capacity : 225 t

Hoisting speed : 1.25 m/min

Rope drum dia., D : 1 400 mm

Number of fall : 20

Rope dia. : 36 mm

Pitch of groove : 39 mm

Rope PCD on drum : 1 436 mm

Calculation,

The D/d ratio = $1400/36 = 38.88$ Rope speed = $20/2 \times 1.25 = 12.5$ m/min

(Minimum 25 m/min rope speed to be considered)

As per Fig. 6 , maximum allowable fleet angle (ϕ) = 4.35 DegreeNow, allowable negative fleet angle (β) $= \phi - \tan^{-1}(p / \pi D)$ $= 4.35 - \tan^{-1}(39 / \pi \times 1436) = 3.854$ Degree**Example 2 : Input data**

Crane capacity : 35 t

Hoisting speed : 8 m/min

Rope drum dia., D : 550 mm

Number of fall : 8

Rope dia. : 22 mm

Pitch of groove : 26 mm

Rope PCD on drum : 572 mm

Calculation,

The D/d ratio = $550/22 = 25$ Rope speed = $8/2 \times 8 = 32$ m/minAs per Fig. 6, Maximum allowable fleet angle (ϕ) = 5.18 DegreeNow, allowable negative fleet angle (β) $= \phi - \tan^{-1}(p / \pi D)$ $= 5.18 - \tan^{-1}(26 / \pi \times 572) = 4.35$ Degree

FIG. 6 MAXIMUM ALLOWABLE FLEET ANGLE

9.3 Where load swinging can occur due to the crane service, rope lead angles shall be set, or other provisions made, to minimize or eliminate the possibility of the rope skipping grooves on the hoist drums. When designing hoist drums the following should be taken into consideration.

9.4 The minimum breaking load F_o of the rope intended for a particular duty shall be determined from the

formula given below, however load amplifying factor shall not be considered while calculating the rope tension:

$$F_o = S \times Z_p$$

Where,

S = maximum rope tension considering inclination of the rope in the upper most position; and

Z_p = minimum practical coefficient of utilization.
Value of Z_p shall be obtained as given below:

Value to Z_p

Group classification of mechanism in accordance with ISO 4301-1 : 1986	Hoisting				Boom hoisting or luffing	
	Single-layer spooling		Multi-layer spooling		Standard rope	Rotation- resistant rope
	Standard rope	Rotation- resistant rope	Standard rope	Rotation- resistant rope		
M1	3.15	3.15	3.55	3.55	3.55	4.5
M2	3.35	3.35	3.55	3.55	3.55	4.5
M3	3.55	3.55	3.55	3.55	3.55	4.5
M4	4.0	4.0	4.0	4.0	4.0	4.5
M5	4.5	4.5	4.5	4.5	4.5	4.5
M6	5.6	5.6	5.6	5.6	5.6	5.6
M7	7.1	7.1	-	-	7.1	-
M8	9.0	9.0	-	-	9.0	-

9.5 Rope Drum

The diameter of the drum / sheave / equalizer measured at the axis of the rope shall be not less than the value calculated as follows:

$$D_d \geq L \times d \times C_{rc}$$

Where,

D_d = Winding diameter on pulleys, drums or compensating pulleys measured at the axis of rope;

d = The nominal rope diameter;

L = Coefficient depending upon mechanism group.
The minimum values of L , for drums, pulleys and equalizer pulleys, as per given Table 5; and

C_{rc} = factor dependent on the construction of wire rope.

For wire rope construction:

- a) 6×36 or 6×37 or compacted : $C_{rc} = 1.0$,
b) 6×24 : $C_{rc} = 1.12$
c) 6×19 : $C_{rc} = 1.25$

Table 5 Value for L
(Clause 9.5)

Mechanism Group	Drums	Sheave	Equalizer
M1	11.2	12.5	11.2
M2	12.5	14	12.5
M3	14	16	12.5
M4	16	18	14
M5	18	20	14
M6	20	22.4	16
M7	22.4	25	16
M8	25	28	18

9.6 Strength of Rope Drum

Drums shall be designed to withstand the compressive stress caused by the wound of wire rope, bending stress due to beam action and torsional stress.

All rope drum shall be checked against crushing stress and permissible compressive stress at the groove when rope is wound on drum.

The rope drum which manufactured from E-250 grade of IS 2062 or ASTM A 106 Gr. A or B material or any other equivalent standard, the minimum permissible crushing stress will be 1100 kg/cm² for M7 and M8 duty cranes and 1250 kg/cm² for M1 to M6 duty cranes.

If rope drum manufactured from E-350 grade of IS 2062 than the minimum permissible crushing stress will be 1 350 kg/cm² for M7 and M8 duty cranes and 1 500 kg/cm² for M1 to M6 duty cranes.

Normally, the rope drum is safe in bending and torsion but longer rope drum should be checked against bending and torsion.

The seamless pipe has more strength against fabricated drum manufactured from steel plates. The grain structures are in circumferential direction in seamless pipe, which is better for withstanding compressive stress. As compressive stress is the prime criteria in rope drum design.

9.7 General

Drums shall be designed for single layer of ropes only and can be designed with multilayer guided rope when agreed to between the manufacturer and the purchaser.

9.8 Length of the Drum

The drum shall be of such length that each lead of wire rope has a minimum of two full turns on the drum when hook is at its lowest position not taking into consideration the turns covered by the wire rope anchorage and one spare groove for each lead of the wire rope on the drum when hook is at its highest position.

In the case where the drum flanges are not provided, a free length not less than 4 times to the diameter of the wire rope or 100 mm dia whichever is more is to be provided beyond the last groove center line at the anchorage point.

9.9 Flanges

The drums shall be flanged at one or both ends in the following conditions such as:

- For single flange drum, at the end where wire rope is released.
- For drums having handed grooves at both ends if wire ropes are released from the end of drums.
- For multi-layer wire ropes at both ends.
- If required by the purchaser.

Where provided, the flanges shall project above the wire rope to a distance not less than 2 times of the wire rope diameter or 50 mm whichever is less beyond the wound rope.

9.10 Grooving of the Drum

Rope drums shall have machined grooves and the contour at the bottom of the grooves shall be circular over a minimum angle of 130° . The lead of the rope shall not exceed 5° (1 in 12) on either side of the helix angle of the groove in the drum.

Grooving shall be finished smooth and shall be free from surface defects likely to injure the wire rope. The edges between the grooves shall be rounded. The radius of the groove shall be between $0.525d$ to $0.550d$ (with $0.537d$ as the optimum see Fig. 7) times the diameter of the wire rope rounded off upwards to the nearest 0.5 mm. The depth of the groove shall not be less than 0.35 (for crane duty upto M 5) or 0.4 (for crane duty above M 5) times the diameter of the wire ropes for drum with single layer of the wire rope.

The grooves of the drum shall be so pitched that there is a clearance between adjacent turns of the rope of not less than:

- 1.5 mm for ropes up to and including 12 mm diameter,
- 2.5 mm for ropes above 12 mm diameter and including 28 mm diameter, and
- 3.0 mm for ropes above 28 mm diameter.

The depth of the groove shall not be less than 0.2 times the diameter of the wire rope for multiple layers of wire rope on the drum. The pitch of the grooves of the drum

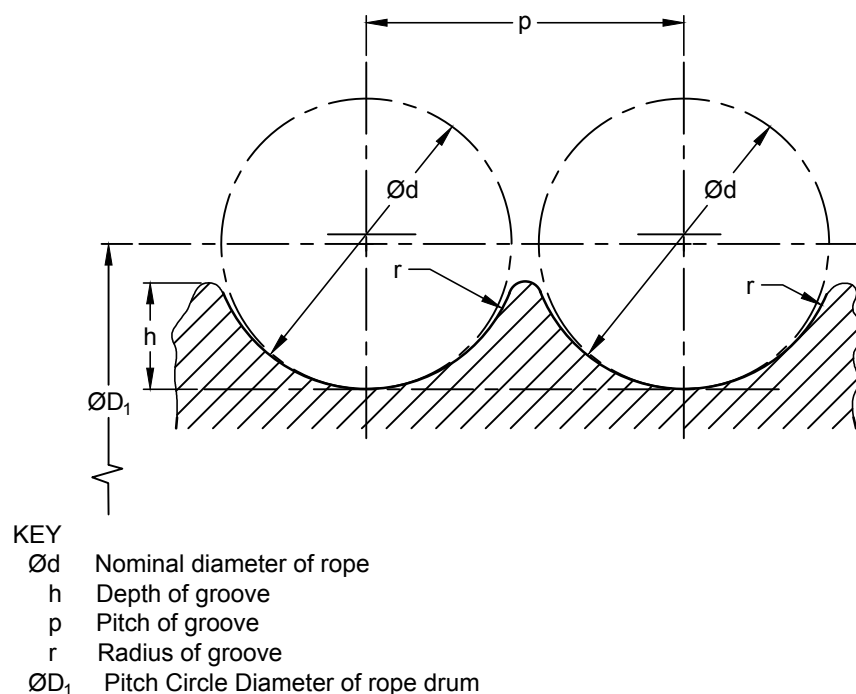


FIG. 7 DRUM GROOVE DESIGN

shall not be less than 1.05 times the diameter of the wire rope for multiple layers of the wire rope on the drum.

9.11 Material for the Drum

Drums shall be made of seamless pipe as per ASTM A 106 GR A or B, cast iron of minimum Grade 25, cast steel, rolled steel of welded construction and in case of welded drum this should be stress relieved.

9.12 Rope Anchorage

The end of the wire rope shall be anchored to the drum in such a way that the anchorage is readily accessible. Each wire rope shall have not less than two full turns on the drums when the hook is at the lowest position not taking into consideration the turns covered by the wire rope anchorage.

10 SHEAVES

10.1 The minimum pitch diameter of sheaves for all crane class shall be selected based on formula given in 9.5. Use the next larger size diameter for lead sheave. Sheaves shall be enclosed by guards which fit close to the flanges to prevent the ropes from coming out of the grooves. The material of the sheaves shall be as per IS 1030. The bearing assembly in each sheaves shall be individually lubricated. The fittings and grease lines shall be located so that they will be protected from damage. Where possible, upper sheave block mountings shall be above the trolley deck. The upper sheaves block shall be removable as a unit from the above. The diameter at the bottom of the groove may be selected from the preferred values that is, 125, 160, 200, 250, 320, 400, 500, 560, 630, 710, 800, 900, 1 000 and 1 120 mm.

10.2 Grooving

Sheaves shall have machined groove. The contour at the bottom of the groove shall be circular over a minimum angle of 130° and shall have an included angle of 45° to 60° proportional to fleet angle of rope. The depth of the groove shall not be less than 1.5 times the diameter of the rope. The radius of the groove shall be between 0.525 to 0.550 times the diameter of the wire rope rounded of upwards to the nearest 0.5 mm on higher side.

11 EQUALIZER BARS OR SHEAVES

Where required, either an equalizer bar or sheave will be acceptable. In either case the bar or sheaves shall be positioned to be accessible from the floor of the trolley and made in such manner that it can turn or swivel to align itself with the pull of the ropes. The minimum pitch diameter of equalizer sheaves shall be selected based on formula given in 9.5. Cranes having hoists which handle hot metal or critical loads should

utilize equalizer bars to provide two independent rope systems, not equalizer sheaves. For increased rope life, consideration shall be given to using equalizer sheaves with the same diameter as the running sheave. The diameter shall be selected from the below preferred values, 125, 160, 200, 250, 320, 400, 500, 560 and 630 mm.

12 TRACK WHEELS

12.1 General

All track wheels shall be double flanged. In case of under slung crane bridge wheel and in single girder cross travel wheel may be of single flange. The wheel shall be made by roll forming, forging or casting from grades of steel appropriate to the forming process. The wheel can also be made from forged tyre shrunk on cast steel, if agreed between the purchaser and the manufacturer. Bridge track wheels shall have either straight or tapered treads. The material of the wheels shall be of grade C55Mn75 of IS 1570 (Part 1 and Part 2/Sec 2) or 42CrMo4 or equivalent. Bridge wheel loads (P_{max} and P_{min}) shall be determined with the maximum lifted load on the trolley, which shall be positioned at the closest working approach that produces the maximum wheel load. Trolley wheel loads shall be determined with the maximum lifted loads:

$$\text{Maximum lift load} = (W_T + W_L + W_A)$$

Where,

W_T = Total weight of trolley including mast if any,

W_L = weight of the lifted load, and

W_A = Weight of lifting appliances if any.

12.2 Wheel Hardness

The hardness of the wheel rim shall be maintained between 300 and 350 BHN with minimum depth of 10 mm. If hardness of the wheel rim more than 350 BHN is required, it shall be decided as per agreement between the purchaser and the crane supplier. The limiting pressure value (P_L) of wheel materials are mentioned in Table 6 which is to be considered while selection of wheel diameter.

In case, if crane wheels are to be manufactured from alloy steel or high tensile steel and treated to ensure very high surface hardness, the value of P_L is limited to that for the quality of the steel comprising the wheel prior to surface treatment according to Table 6. The higher value of wheel hardness will give better life however, would risk causing wear of the rail and possibility of crack generation during shock loads. The hardening of the wheel tread at the depth of 0.01 D may be taken into account when selecting the value of P_L .

Table 6 Values of P_L
(Clauses 12.2 and 12.3)

Ultimate Tensile Strength for Metal Used For Rail Wheel N /mm ²	P_L In N /mm ²	Minimum Strength for the Rail, in N /mm ²
$\sigma_t > 500$	5.0	350
$\sigma_t > 600$	5.6	350
$\sigma_t > 700$	6.5	510
$\sigma_t > 800$	7.2	510
$\sigma_t > 900$	7.8	600
$\sigma_t > 1\ 000$	8.5	700

12.3 Diameter of the Wheels

Wheels may be either double flanged or flangeless with guide rollers.

The tread diameter of wheels shall be standardized to sizes 160, 200, 250, 320, 400, 500, 630, 710, 800, 900, 1 000, 1 120 and 1 250 mm. While doing selection of the rail wheel, following points to be checked,

- It should be capable of withstanding the maximum load to which it will be subjected.
- It will allow the crane / trolley to perform its normal duty without abnormal wear.

The minimum diameters of wheel can be determined based on below formula:

$$D \geq \frac{P_{\text{mean}}}{P_L \times w \times c_1 \times c_2}$$

and the maximum allowable load can be verified based on below formula.

$$P_{\text{max}} \leq 1.9 \times P_L \times D \times w$$

Where,

D = Minimum wheel diameter, in mm;

w = Useful width of rail, in mm;

P_L = Limiting pressure of wheel depending on wheel material, in N / mm² as mentioned in Table 6;

c_1 = A coefficient depending on the speed of rotation of the wheel and are given in Table 7;

c_2 = A coefficient depending on the group mechanism and given in Table 8; and

P_{mean} = The mean wheel load, in N.

While calculating wheel load amplifying factor is not applied.

Table 7 (Value of c_1)
(Clause 12.3)

Wheel Rotation Speed in RPM	c_1	Wheel Rotation Speed In RPM	c_1	Wheel Rotation Speed in RPM	c_1
200	0.66	50	0.94	16	1.09
160	0.72	45	0.96	14	1.10
125	0.77	40	0.97	12.5	1.11
112	0.79	35.5	0.99	11.2	1.12
100	0.82	31.5	1.00	10	1.13
90	0.84	28	1.02	8	1.14
80	0.87	25	1.03	6.3	1.15
71	0.89	22.4	1.04	5.6	1.16
63	0.91	20	1.06	5	1.17
56	0.92	18	1.07	—	—

Table 8 (Values of c_2)
(Clause 12.3)

Group Classification of Mechanism	c_2
M1 and M2	1.25
M3 and M4	1.12
M5	1.00
M6	0.90
M7 and M8	0.80

12.4 Determining the Mean Load

In order to determine the mean loads, the procedure is to consider the maximum and minimum loads with stood by the wheel in the loading cases considered, that is, with the crane in normal duty but omitting the dynamic factor

The values of P_{mean} shall be determined by the following formula and it is applicable for all cases of loading conditions mentioned in 7.3.2:

$$P_{\text{mean}} = (P_{\text{min}} + 2 P_{\text{max}}) / 3$$

Where, P_{min} and P_{max} depends on loading condition.

12.5 Determination of Wheel Bearing Surface/ Useful Width of Rail

- Flat bearing surface : $w = B - 2r$
- Convex bearing surface : $w = B - 4r/3$

where,

B = width of the rail, and

r = radius of the rounded corners of the side.

12.6 Flanges

Dimensions of flanges for guiding tread wheels at the base shall not be less than the values given in Table 9.

Table 9 Minimum Flange Dimensions

(Clause 12.6)

All dimensions in millimeters

Sl No.	Diameter of Wheels	Depth of Flange	Thickness of Flange
(1)	(2)	(3)	(4)
i)	160, 200, 250,	16	16
ii)	315, 400, 500	20	20
iii)	630, 710, 800,	25	25
iv)	900, 1 000 , 1 250	30	30

12.7 Width of Tread

The width of the wheel tread shall be greater than the rail head by an amount which shall suitably allow for the variations in the gantry rail alignment, gantry track span dimensions and crane span dimensions.

12.8 Adhesion of the Drive Wheels

To eliminate slipping of the drive wheels of the travelling mechanism of the crane or crab, the design shall be checked for adhesion under the most unfavourable combination of loads producing maximum and minimum loads on the drive wheels. The co-efficient of adhesion (friction) shall be taken as 0.2 for dry rails and 0.15 for damp rails.

13 BUFFERS

13.1 Provisions in the design of the runway and the design of the runway stops shall consider the energy absorbing or storage device used in the crane bumper. The device may be non-linear (for example, hydraulic bumpers) or a linear device, such as, a coil spring. Other types of buffers like hydraulic and resilient plastic buffers may also be used subject to agreement between the manufacturer and the purchaser.

13.2 Buffers shall have sufficient energy absorbing capacity to bring unloaded crane / trolley (loaded crane in the case of stiff masted cranes) to rest from a speed of 50 percent of the rated speed at a deceleration rate not exceeding 5 m/s².

13.3 Between cranes or trolleys (if two trolleys are located on one bridge) bumpers shall be capable of absorbing the energy from 70 percent of full load rated speed of both cranes or trolleys travelling in opposite directions, or the energy from 100 percent of full load rated speed of either crane or trolley, whichever is the greatest.

13.4 The design of all bumpers shall include safety cables to prevent parts from dropping to the floor. For computing bridge bumper energy, the trolley shall be placed in the end approach which will produce the maximum end reaction from both bridge and trolley. This end reaction shall be used as the maximum weight portion of the crane that can act on each bridge bumper. The energy absorbing capacity of the bumper shall be based on power-off and shall not include the lifted load, if free to swing. Bridge bumpers shall have a contact surface of not less than 125 mm in diameter, be located on the rail centreline and mounted to provide proper clearance when bumpers of two cranes come together and both are fully compressed. Where practical, they shall be mounted to provide for easy removal of bridge track wheels.

13.5 If required by the customer, buffer may be designed at 0.7 times of the rated speed.

14 SHAFTS

14.1 General

Hoist shafting design torque shall be based on the torque required to lift the rated load plus hook block and/or lifting beam and shall take account of mechanical efficiencies. Design torque for all travel drives shall be based on 2 times the 60 min motor rating for series wound, constant potential d.c. drives, and 1.7 times the 60 min motor rating for a.c. motors and adjustable voltage d.c. drives without motor field weakening, or wheel slip at maximum wheel load (0.20 friction factor), whichever is lower. Due consideration shall be given to the maximum brake torque which can be applied to the drive. Axles or shafts which are provided with sleeve bearings are to be surface or case-hardened and ground.

14.2 Shaft Material

All shafts shall be made of low alloy steel in addition to C 45 and axles shall have strength, rigidity and required the bearing surfaces. All rigid shafts shall be supported on two bearings. Angular deflection of the line shaft at torque corresponding to 1.5 times the motor torque during the acceleration period shall not be more than 0.3° / m of shaft length. The drive for line shaft shall be mounted as close as practicable to the centre of the span.

14.3 Stress Calculations

All shafting shall be designed to meet the stresses uncounted in actual operation. Due consideration shall be given to the maximum torque which may be applied to the shaft. When significant stresses are produced by the other forces, these forces shall be positioned to provide the maximum stresses at the section under consideration. Impact shall not be included wherein C_{df} value has been considered.

14.4 Fatigue Stress Check for Normal Operating Conditions

Any shafting subjected to fluctuating stresses, such as, the bending or rotating shafts or the torsion in reversing drives must be checked for fatigue. The bearing stress must not exceed 50 percent of the minimum yield strength for non-rotating shafting.

15 PRESS FITS AND KEYS

All gears, pinions and couplings shall be pressed and keyed and/or shrunk onto shafts. All press fits shall be made in accordance with IS 2048. All keys and keyways shall be radiused and/or chamfered according to relevant Indian Standard.

16 BEARINGS

16.1 Anti-friction bearing shall be used throughout except where specified otherwise or mutually agreed. Anti-friction bearing shall be self aligning spherical roller for wheel and self aligning spherical roller/ taper roller/ ball bearing for all gear boxes and cylindrical roller/ ball bearing for pulley as per duty class. Anti-friction bearing shall be selected for minimum 10 years life. The minimum bearing life (in hours) as per their class duty are mentioned below:

Duty Class	Minimum Bearing Life (in hours)
M1	1 250
M2	1 250
M3	2 500
M4	6 300
M5	10 000
M6	15 000
M7	30 000
M8	50 000

Antifriction bearing to be checked for the static load to which it can be subjected under whichever of loading cases I, II or III (*see 7.3.2*) is the most unfavourable. Bearing selection in this specification is based on the total number of cycles which it is expected the bearing will undergo during the number of hours service the crane will be used in a 10 year period.

16.2 All bearings selected shall meet the required life at bearing load (at rated speed) based on bearing manufacturer. If the load on the bearing is essentially constant, the bearings must meet a required life of 100 percent of the maximum load at rated speed. In some cases axle sizes establish bearing sizes. With wheel bearings of the antifriction type, one bearing on each wheel axle shall be of the fixed type. The other

bearing shall be arranged to allow for expansion or float of the axle.

16.3 Lubrications

Provisions shall be made for the service lubrication of all the bearings unless sealed and lubricated for life. Ball and roller bearings shall be lubricated before assembly. Gear housings shall be split or designed to permit easy removal of the shaft. Gear reduction units should be designed so that gears, shafts and bearings, can be pre-assembled as a spare.

16.4 Bearing Brackets and Housing

Bearing brackets, if not integral with the frame, shall be mounted on a machined surface and be kept in alignment by fitted bolts or other equally effective methods. When shafting is geared together the support structure for all bearing cartridges should, where practical, be integral and located as close as possible to the gears and pinions. Heavy caps shall be provided with a means for lifting.

17 GEARING

17.1 Gearing Types

Gearing shall be spur, herring bone, helical as specified in the IS 4460 (Part 1 to 3), IS 7504. No split gears shall be used. As far as possible overhung gears should be avoided.

17.2 Gearing Design

Horsepower ratings for all spur and helical involute gearing shall be based upon American Gear Manufacturers Association or IS 4460 (Part 1 to 3).

17.3 Gear Design Loading

Hoist gear loading for bending strength and pitting resistance shall be based on the torque required to lift the rated load plus hook block and/or lifting beam. Travel drive gear ratings for bending strength and pitting resistance shall be based on 2 times the 60 min motor rating for series wound constant potential d.c. drives, and 1.7 times the 60 min motor rating for a.c. motors. Due consideration shall be given to the maximum brake torque which can be applied to the drive.

17.4 Dynamic Response

Where unusual drive arrangements are employed the dynamic response of the system should be analyzed to ensure that any additional loadings are identified and mitigated for operational requirements and life expectancy of crane.

17.5 Drum Gear Alignment

The effects of trolley frame and rope drum deflections on the alignment of the hoist drum gear and pinion shall be considered.

18 MACHINING REQUIREMENTS OF GEARS

18.1 Machining and Inspection

All gears shall be preferably 20° pressure angle full depth tooth form and shall have a full root radius unless this compromises other design considerations. The wall thickness over the keyway of pinions shall be at least equal to the tooth depth and the rim thickness of gears shall be at least 1.2 times the tooth depth. Gears shall not have a shoulder or step left in the fillet area.

18.2 All gears shall be hardened and machine cut and may be profile ground. The gears shall conform to relevant Indian Standards. The gearing shall be designed for a service life compatible with the service life of the mechanism, the class of utilization and state of loading used for the mechanism, and having regard to the prime mover and brake.

19 GEAR BOXES

19.1 Material

All gears shall be of cast or wrought steel or forged steel of low or medium carbon steel or alloy steel and suitably heat treated and/or case carburized.

19.2 All gears shall be completely enclosed in gear boxes which shall be attached to rigid supports. All gear boxes except for drum ring gears shall be oil-tight and sealed with compound or gaskets. The bottom of the gear boxes shall be split horizontally above the oil level. Easily accessible drain plugs and breathers shall be provided. Oil level dipsticks shall go directly into the main body of gear box.

19.3 Openings shall be provided in the top section for the inspection of gearing at mesh lines. Gear box inspection cover plates should provide reliable sealing and be easily opened and re-sealed.

19.4 Splash oil lubrication of bearings may be used unless otherwise specified. Oil pumps shall be used, if vertical gearing exceeds two reductions. On horizontal gearing, the oil level shall be above the smallest gear. Oil seals shall be sized to allow replacement with split seals. Through bolts should be used to hold the gear cases together and to mount the gear box to its base. All gear cases shall be mounted on machined surfaces. Shims shall not be used.

19.5 Gear box seats shall be of sufficient size to allow the installation of shear blocks to locate the gear box positively. Gear boxes shall be provided with lifting lugs that are suitable for use in lifting the whole gear case assembly without tilting.

19.6 All pair of gearboxes shall be preferably helical, except for planetary portion of gearboxes shall be spur. The gears shall be automatically splash /forced oil lubricated. The gears shall be readily removable

and the boxes shall be oil tight. They shall be of rigid construction and fitted with inspection covers and lifting lugs, where necessary. The inspection covers shall be so positioned that the first and second pinion shafts can be inspected. Minimum and maximum oil level indicators and facilities for oil filling, oil drainage and air breathing shall be provided. All gear boxes shall be in totally enclosed construction. Teeth shall be machine cut, suitably hardened and tempered and shall conform to IS 4460 (Part 1 to 3) or AGMA. The surface hardness of pinion shall be minimum 270 BHN and that for gear shall be minimum 220 BHN. Difference of hardness of pinion and gear shall not be less than 20 BHN (except for case carburized gears). The gear box mounting shall be machine cut, seated and positively located on machined surface. Material of the gear box housing shall be cast or fabricated. The fabricated gear boxes shall be stress relieved before machining. The internal surfaces of the gear box shall be painted with oil resisting paint.

19.7 If desired by purchaser, molten metal handling crane, main hoist mechanism shall be provided with planetary gearbox with dual drive system to facilitate uninterrupted operation without overloading of the hoist mechanism, so that the main hoist can be operated with one motor at half the rated speed when other motor fails.

19.8 Shaft mounted geared brake motor for travel drive in CT and LT may also be used.

20 CRANE LUBRICATION SYSTEM

20.1 Following types of lubrication system may be considered as per requirement:

- a) Point lubrication;
- b) Semi centralized (Bunched) lubrication;
- c) Dual line centralized motorized lubrication system;
- d) Dual line centralized lubrication system with manual pump;
- e) Rail track lubrication system; and
- f) Wire rope lubrication system.

All lubrication lines shall be suitably located to prevent any mechanical damage.

20.2 Provisions shall be made for lubricating all bearings unless sealed or lubricated for life, mating gears and chain and sprockets arrangements, where necessary easy access shall be provided.

21 LINE SHAFTING AND COUPLINGS

21.1 Floating Shaft

Where possible, the flexible halves of half flexible couplings shall be mounted on the floating shaft.

Couplings shall be located close to the bearings and be provided with substantial removable guards which shall extend beyond the ends of the hubs and overlap with the coupling hub outer diameter. Where half-flexible couplings are used, the couplings shall be located close to the bearing on the end track and the adjacent line shaft bearing shall not be closer than 1 250 mm.

21.2 The load shall be transmitted between couplings half by means of fitted bolts. For shaft speed below 400 rpm, the following maximum bearing spacing shall be permitted:

- a) 3.5 m for 75 mm diameter;
- b) 4.25 m for 90 mm diameter;
- c) 4.5 m for 100 mm diameter; and
- d) 4.85 m for 115 mm diameter .

21.3 For shaft speed in excess of 400 rpm, the above spacing shall be reduced as necessary to avoid harmonic vibrations. Supports for motor and gear reduction units shall be welded structural steel, rigidly connected to the crane girder. Bolts for fastening bearing brackets, motors and gear reduction unit shall be accessible from above the foot walk. Angular deflection of bridge line shafts at torque shall not exceed 0.3°/m of shaft length.

21.4 For connection between the hoist gear box and rope drum the following options may be considered as required:

- a) Built in geared coupling;
- b) Barrel coupling; and
- c) Any other suitable flexible transmission system as per requirement of the purchaser or design.

22 RAILS

22.1 Rail shall be as per IS 3443 or equivalent, rectangular bar or square bar of weldable steel (of high tensile steel) may also be used depending on capacity and duty of crane. Rail joint shall be secured by clamping or welding.

22.1.1 Joints on trolley rail shall be clamped /welded / made by using standard joint bars. There shall be no bolt holes adjacent to the welded joint.

22.2 For box girders, rails shall be fastened in place by suitable clamps or square / rectangular bars can be welded to top of girder. Suitable wear plate may be provided below rail so as to avoid wear and tear or girder top flange, if agreed between the manufacturer and the purchaser.

22.2.1 The rail clamping may be of soft mounting system consist of pad and clips, if agreed between manufacturer and purchaser in lieu of standard steel rail clamps. The clamps shall be spaced at not more than 900 mm between centres.

23 OPERATOR'S CABIN

23.1 Type and Location

Based on purchaser's requirement, the operator's cabin may be of the fixed / moving type, open / enclosed type.

23.2 Structure

The cabin shall be rigidly built of structural steel and fire proof material for molten metal crane and shall be braced to prevent movement between cabin and supporting members. It shall be supported by rivets or bolts in shear. The head room of the cabin shall not be less than 2 m.

23.2.1 Driver's Cabin

23.2.2 Driver's Visibility

Driver's cabin shall be designed so that the driver has a clear view of all working areas.

23.2.3 Cabin Dispositions

The driver's cabin shall have sufficient room for the driver to be able to reach or leave the controls without hindrance. Controls shall preferably be operated from a sitting position, but also from a standing, when necessary.

23.2.3.1 Driver's cabin shall have a minimum head room of 2 m and shall be fitted with a guardrail of at least 1.0 m high.

- a) A protective shield shall be installed above the driver's cabin when there is any danger of falling object.
- b) The layout of the cabin and controls shall be ergonomically designed.

23.2.4 Heat Insulated Material (For Molten Metal Handling Crane, if Required by Purchaser)

The structural frame work of the driver's cabin shall be non-combustible material, and the side panels and roof may optionally be of fire resistance materials. The floor of the driver's cabin shall be covered with non-metallic, heat-insulating material.

23.2.5 Glazed Windows and Entrances

Entrances shall be protected against accidental opening sliding doors and out ward opening doors of driver's cabin must lead on the landing. The drivers cabin's windows shall be provided with suitable safety glass to avoid the risk of breakage.

23.2.6 Anti-glare Lighting and Heating

Driver's cabin shall be provided with adequate anti-glare lighting to allow handling of the controls and, if necessary, may be ventilated.

23.2.7 Heat-proof

Driver's cabin which are exposed to radiant heat shall be protected heat radiation, and of a heat proof design, and if required by the purchaser air-conditioned may be provided to ensure tolerable working conditions.

23.2.8 Following shall be provided at the appropriate location:

- a) Emergency stop and reset device;
- b) Electrically operated audio warning device, audible at minimum distance of 30 m; and
- c) Adequate illumination.

23.3 In ladle cranes, other cranes handling hot materials and outdoor cranes, cabins shall be totally enclosed, unless otherwise specified.

23.4 The cabin of outdoor cranes shall be weather proof. If the cabins are fitted with opening windows, these shall be hinged or made to slide as per manufacturer's standard practise. If special vision panels are provided in the floor, they shall be suitably guarded. Arrangement shall be made to ensure that the whole exterior of the cabin glazing can be safely cleaned. Glasses shall be mounted with proper rubber seals/ beadings and shall be able to with stand vibration. All glazing shall be toughened plate glass of 6 mm minimum thickness conforming to IS 2553 (Part 1) and shall be installed from inside. Heat shield shall be provided below the cabin of hot metal handling crane.

23.5 Cabin Access

Access to open cabins via rung ladder or staircase from walkway, the entrance to the cabin shall be fitted with a door located for safe access. The cabin floor shall be extended outside the cabin on the side containing the door, and if necessary, sideways also to form a platform unless otherwise required. Suitable hand railing should be provided on the platform.

23.6 Accessibility to the bridge platform shall be through the stairs. However, in case of space constraints ladders may be provided, if required.

23.7 Visibility and Field of Vision

Cabins shall be so designed that under all operating conditions the field of vision of the driver is adequate.

23.8 Lighting, Heating, Ventilation and Air-conditioning

Fixed service lighting shall be installed to provide glare free illumination in the crane cabin. All cabins shall be provided with an air circulating fan of minimum sweep 400 mm. All air-conditioned cabins shall be fitted with a suitable hydraulic door closer and temp in the cabin shall be around 25°C.

23.9 A suitable carbon dioxide (CO₂) type fire extinguisher shall also be provided.

23.10 The cabin shall have a robust seat with a fixed or hinged or swivelling base and a durable upholstered squab. The seat shall be capable of withstanding severe braking force.

24 GANGWAYS AND PLATFORMS

24.1 Cabin Access

24.1.1 Easy and safe access to the driver's cabin must possible in any position under normal working conditions.

24.1.2 The driver's cabin shall be fitted with suitable emergency exit.

24.1.3 Entry to the driver's cabin should be preferably from a platform at the same level as the floor of the cabin and provided with guard rails.

24.2 Access to Gang Ways, Stair Ways and Platforms

Gangways, stair ways and platforms must have safe access in any position.

24.3 Maintenance Areas

All operating locations and all equipment of the crane which requires regular inspection or maintenance must be provided with safe access. Arrangement shall be provided to ensure that whole exterior of the cabin glass shall be safely cleaned without any additional scaffolding.

24.3.1 Head Room

Stair ways, gang ways and platforms shall have a head room of not less than 2 m and clear passage way of not less than 600 mm wide must be provided.

24.3.2 Guard Rail

Guard rails shall be not less than 1 m height and shall be provided with toe guards and intermediate rails.

24.3.3 Slip-proof Surfaces

Platform surfaces shall be suitably slip-proof. Holes, gaps and openings in the flooring shall be restricted in size so that a 20 mm diameter ball can't pass through.

24.3.4 Power Line Protections

When gang ways are located adjacent to power lines, these lines must be protected against accidental contact.

25 GUARDING

25.1 All gear wheels, pinions and chain drives shall be totally enclosed. Effective guards shall be provided for revolving shafts and couplings. Long travel cross-shafts and couplings above the top platform shall be guarded wherever necessary. The sheaves of hook blocks shall be guarded to prevent the trapping of a hand between a sheave and the in-running rope and shall be enclosed except for rope opening.

25.2 Safety features in hook blocks, pulleys and other load carrying devices.

25.2.1 *Prevent to Jumping*

Adequate means shall be provided to prevent the rope from jumping of the pulleys.

25.2.2 *Hand Guard*

An adequate guard shall be provided where there is any danger of a hand being trapped between the rope and the pulley of the hook block.

25.2.3 *Maintenance*

Rope pulleys shall be designed so as to be accessible for maintenance.

25.2.4 *Working Load Name Plate*

Inter changeable load carrying devices, such as, grabs, lifting magnets, tongs and lifting beams shall be permanently marked with their safe working load and dead weight and also, in case of grabs and buckets their capacity and name of manufactures.

26 WEATHER PROTECTION

For outdoor cranes, all electrical equipment shall be adequately protected from weather. All weather proof covers shall be easily removable.

27 PAINTING

27.1 Before dispatch of the crane, the complete crane covering structural, mechanical and electrical parts shall be thoroughly cleaned of all dirt, grease, scale and rust by shot blasting or chemical cleaning methods. Suitable number of coats of primer shall be given to all parts exposed to the weathering effects and if are not already treated earlier or effectively lubricated. At least two additional finishing coats of paint for indoor cranes/outdoor cranes of colour of customer's choice shall be given on all primer painted surfaces.

27.2 All moving parts up to the height of 5.0 m from working level or ground shall be painted in 'Golden Yellow' colour. The bright exposed parts of the crane shall be given one coat of rust inhibitor. Interior of all gear boxes shall be painted with one coat of oil resisting paint. Areas that are inaccessible after assembly or erection shall be treated before assembly or erection.

27.3 Where the cranes are supplied for use in abnormal working conditions special protection may be necessary. Any additional requirements regarding painting shall be as agreed between the purchaser and the manufacturer.

28 HANDLING FACILITIES

28.1 Suitable structure at all four corners for handling the track wheels shall be provided for outdoor cranes.

However, for all outdoor goliath and semi-goliath cranes, this facility shall be provided.

28.2 All cranes shall be provided with jack pad on both end carriages and trolley structures in such a way so as to facilitate removal of wheels, wheel bogie and compensating bogie.

29 BRIDGE AND TROLLEY DRIVES

29.1 Bridge and trolley drives arrangements may cover most types of crane drives regardless of the number of wheels.

29.2 Bridge and Trolley Drive

Bridge and trolley drive may consist of one of the following typical arrangements (*see* Fig. 8) and these arrangements cover most four or eight wheel crane drives:

29.3 A1 Drive

The motor is located near the centre of the bridge/trolley and connected to a self-contained gear reduction unit located near the centre of the bridge/trolley. Output of the gear reduction shall be connected directly to the track wheel axle by means of suitable shafts and couplings.

29.4 A2 Drive

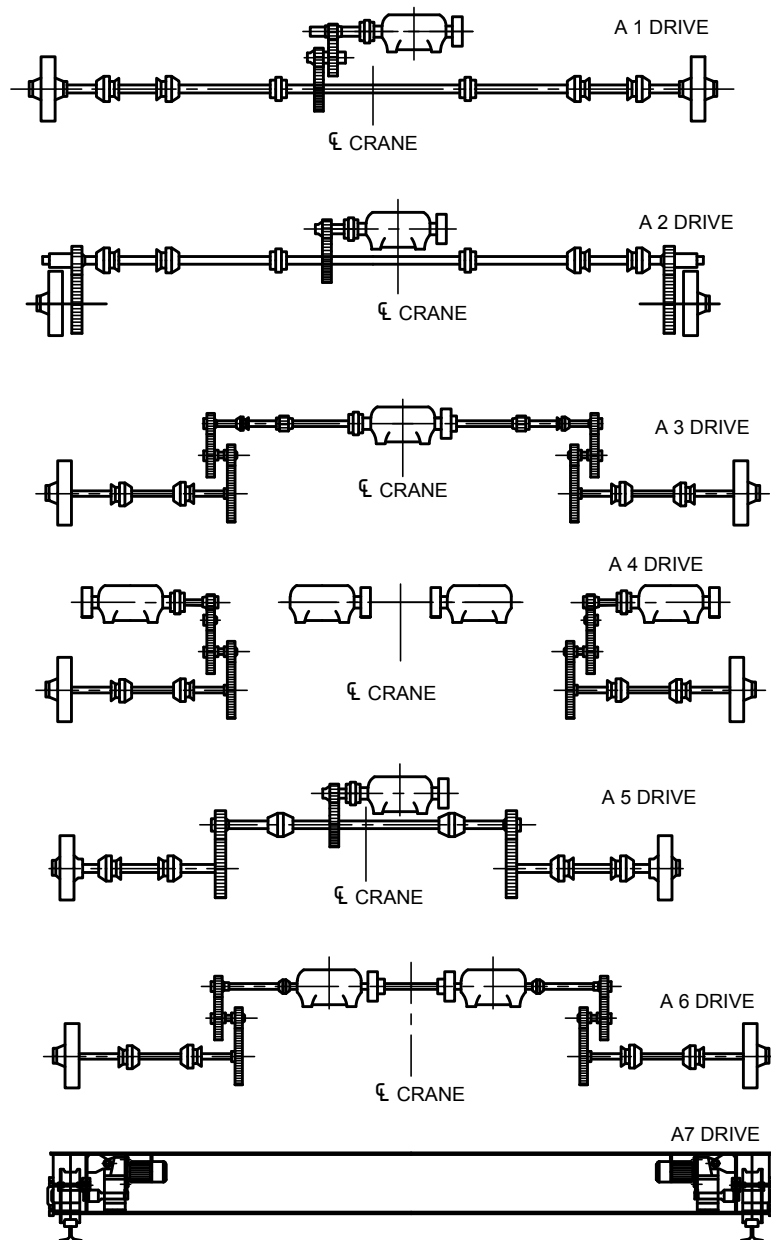
The motor is connected to a self contained gear reduction unit located near the centre of the bridge/trolley. The track wheels shall be driven through gears pressed and keyed on their axles or by gears fastened to, or integral with, the track wheels and with pinions mounted on the end section of the cross-shaft. The end sections of the cross-shaft shall be connected by suitable couplings.

29.5 A3 Drive

The motor is located at the centre of the bridge/trolley and is connected to the cross-shaft and gear reduction units with suitable coupling. Self-contained gear reduction units located near each end of the bridge/trolley shall be either directly connected to the wheel axle extension or connected to wheel axles by means of shafts in the suitable couplings.

29.6 A4 Drive

The motors are located near each end of the bridge/trolley without torque shafts. The motors shall be connected to self-contained gear reduction units. The gear reduction unit shall be applied to the track wheels by means of both suitable shafts and couplings or directly mounted to the wheel axle shaft extension. Another variation of this drive would separate the high speed and final reductions by locating the motors near each end of the bridge without torque shafts.



Note - Other arrangement may also be considered if required.

FIG. 8 TYPICAL ARRANGEMENT OF BRIDGE AND TROLLEY DRIVE

29.7 A5 Drive

The motor is located near the centre of the bridge/trolley and is connected to a self-contained gear reduction unit located near centre of the bridge/trolley. This reduction unit shall be connected by sections of cross-shaft having suitable couplings to self-contained gear reduction units located near each end of the crane, and these in turn connected to track wheel axle by means of shafts with suitable coupling.

29.8 A6 Drive

The motors are located near each end of the bridge/trolley and connected with a torque shaft. On the drive end, the motors shall be connected to self-contained gear reduction units by suitable couplings. The output of the gear reduction units shall be connected directly to the track wheel axle by means of suitable shafts and couplings.

29.9 A7 Drive

The geared brake motors are mounted on the wheel shaft with torque arm to transmit the torque to the driving wheel. This arrangement is an alternative of A4 drive (*see* 29.6) which is compact and ensure life time alignment of the drive.

29.10 Percentage of driving wheels may be 16.66, 25, 33.33, 50 or 100 depending on the requirement. While selecting the percentage of driving wheels, it shall be ensured that there is no skidding.

30 TORSIONAL, DEFLECTION AND VIBRATION

Natural frequency and amplitude of total torsional deflection of the drive system should be determined. Low frequencies and large total torsional deflections are undesirable for crane operation.

31 MOTION LIMITING DEVICES

Positively operated hoisting motion limiting devices shall be provided that stops the upward and downward motion when predetermined level is reached to prevent over winding or over unwinding. Pre-limit switch shall also be provided for slowing down before the final limits are actuated wherever control system permits variable speed.

NOTE — The limiting device shall be regarded as a safety feature and not as a routine operational means of stopping. Where normal operation of the crane necessitates frequent approach to the upward limit, an additional motion limiting device shall be provided that operates independently and require manual settings.

32 CROSS TRAVEL AND LONG TRAVEL LIMITING DEVICES

The limiting devices shall prevent the following conditions:

- a) Over traversing and over travelling, or
- b) Collision where two or more crane/trolleys operating on the same track/ different track at different level in the same bay (if specified).

Pre-limit switch shall also be provided for slowing down before the final limits are actuated wherever control system permits variable speed.

33 LOAD LIMITING DEVICES

Load limiting devices are recommended, if weights of objects to be lifted are not known accurately. When fitted, they shall sense the load on the crane by means other than the current consumed by the hoist motor. If the load lifted is more than *SWL*, load limiting devices shall stop further hoisting operation till the load is removed or reduced. If required by purchaser, load indication may be suitably provided. This arrangement is to be provided, if specifically asked by purchaser.

34 DRAWINGS AND DOCUMENTS

Depending on the extent of agreement with purchaser, following drawings and documents shall be submitted for approval of the purchase before manufacturing of the crane:

- a) GA drawings of the crane;
- b) GA drawings of crab/trolley;
- c) GA drawings of individual mechanisms;
- d) Drawings of bridge, end girder and their connection;
- e) Sub-assembly drawing for wheels, hook blocks and hoist drums;
- f) Calculation for selection of motor, reducer, brake, couplings, etc.;
- g) Layout of cabin showing the location and fixing of all the equipment inside it;
- h) Lubrication arrangement for the complete crane; and
- j) Quality assurance plan for inspection

SECTION 3 ELECTRICAL EQUIPMENT

35 POWER SUPPLY

35.1 General

This standard deals with a.c. low voltage systems up to 1 000 V. The power supply system should comply with relevant Indian Standards. Voltage variation at the point of supply to crane DSL system be limited to ± 5 percent of the rated voltage under normal operating conditions. The end user shall ensure this with respect to number of cranes in the bay with dedicated feeding transformer or feeder, etc. For applications with very long cabling distances it may be necessary to limit the voltage variation further. The allowed voltage drop (percent) in the different parts of the power supply need to be considered case by case. The type of the power supply grounding may have significant effects on the requirements of the crane electrification. The type should always be as agreed to between the purchaser and the supplier. For cranes with incoming power requirement higher than 1 000 kVA, for example, ladle crane, the system voltage should be designed preferably at 415/ 690 V a.c. in order to optimize the sizes of conductor, cables, motors and controls.

35.2 DSL Systems and Accessories for Cranes

35.2.1 General

Down shop lead arrangement using GI, copper, aluminum or steel sections with or without shrouding or by using flexible trailing cable arrangement or with drag chain/cable reeling drum may be used.

35.2.2 Conductors

Current conductor system or DSL system shall be provided either by the purchaser or by the crane manufacturer as agreed by them. Cranes operating on bare conductors shall be equipped with suitable guards to prevent ropes or suspended load coming in contact with the live conductors due to swing of the hook block. Down-shop conductors also shall be screened to prevent contact while handling long lengths of conducting materials from floor.

35.2.3 Current Collectors

Unless otherwise agreed to, all collector assembly shall be supplied by the crane manufacturer. The purchaser shall furnish relevant details depending upon the manufacturer's scope of work. Collector rollers or shoes shall be so designed as to minimize/avoid sparking, shall be spring loaded/gravity type and shall be easily replaceable. Collector assembly shall be mounted on a rigid structure on the crane bridge. Necessary safe and convenient access shall be provided for maintenance or replacement of the collectors. Minimum two current collectors shall be provided per trolley line. Each collector shall be of 100 percent rating of crane total current load.

35.2.4 Rating and size of DSL / Runway Conductor

The total ampere load is determined with full load currents reduced by load diversity factor and duty cycle factor given in Table 10 and Table 11 respectively. The total ampere load shall be considered as per Table 12. After determination of the sequence of the motors with the largest output (ID), the amperages marked with

an "X", plus basic loads for auxiliary load are added together i.e. $I_{DA} = \Sigma I_D + \Sigma I_G$

Current rating of runway conductor = Total load current as per Table 12 $\times f_{ED} \times f_D$

The selected current rating of the runway conductor may be derated by the temperature correction factor as per the manufacturer as applicable.

NOTES

1 In this clause, the rated current (I_N) should be considered not necessarily to mean the name plate current of the motor but the current drawn by the motor at full rated load (that is, FLC corresponding to mechanical kW at rated ambient and duty) .

2 When squirrel cage motor is operated by variable voltage variable frequency converter, the full load current drawn from supply source by VFD line current should be considered for sizing of runway conductor

35.3 Cross Travel Current Collecting System**35.3.1 General**

Cross travel current collecting system shall be with bare conductors or with shrouded conductors or with trailing cable arrangement or with cable drag chain. The collection system shall be provided by the manufacturer.

35.3.2 Conductors

Cross travel conductors for the main trolley shall be mounted on the main bridge platform and not inside the main girders. Conductors for auxiliary crabs shall be mounted suitably above the level of auxiliary trolley rails. Cross travel conductors shall be arranged so that

Table 10 Load Diversity Factor f_D
(Clause 35.2.4)

Sl No.	Duty Class	Diversity Factor for 1 Crane	Diversity Factor for 2 Cranes	Diversity Factor for 3 Cranes	Diversity Factor for 4 Cranes	Drive Diversity Factor for 5 Cranes	Drive Diversity Factor for 6 Cranes	Drive Diversity Factor for 7 Cranes and More
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	M6, M7, M8	1.0	0.95	0.91	0.87	0.84	0.81	0.78
ii)	M5	0.7	0.8	0.65	0.5	0.5	0.5	0.5
iii)	M1 to M4	0.5	0.7	0.5	0.4	0.4	0.4	0.4

NOTE — In case the cranes are of different duty classes, then diversity factor of higher duty class shall be considered.

Table 11 Duty Cycle Factor f_{ED}
(Clause 35.2.4)

Duty Cycle Factor (f_{ED})								
Running period ED	20 percent	30 percent	40 percent	50 percent	60 percent	80 percent	100 percent	
Reduction Factor f_{ED}	0.45	0.54	0.63	0.71	0.78	0.89	1	

Table 12 Equivalent Continuous Current of DSL
(Clause 35.2.4)

Summation of load current	No. of Cranes														
	1			2			3			4			5		
	FLC of Largest Motor		Aux. load	FLC of Largest Motor		Aux. load	FLC of Largest Motor		Aux. load	FLC of Largest Motor		Aux. load	FLC of Largest Motor		Aux. load
	1 st largest	2 nd largest		1 st largest	2 nd largest		1 st largest	2 nd largest		1 st largest	2 nd largest		1 st largest	2 nd largest	
Σ	X	X	X	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Σ	X	X	X	X	X	X	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Σ	X	X	X	X	X	X	X	X	X	n.a	n.a	n.a	n.a	n.a	n.a
Σ	X	X	X	X	X	X	X	X	X	X	X	X	n.a	n.a	n.a
Σ	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X Applicable															
n.a not applicable															
NOTES															
1 With double drives corresponding to 2 X ID , lifting magnet and hoisting unit are counted as one joint drive.															
2 Aux. load such as lighting, A.C, magnet, rotating trolley, brakes etc. as applicable															
3 For multiple motors on single crane or hoist, the minimum current rating of power supply conductors shall be the full load ampere rating of the first largest motor or group of motors for any single crane motion, plus current rating of second largest motor or group of motors operating simultaneously with the first largest motor or group of motors.															

they are all accessible for maintenance from at least one side along the whole length. Bare conductors mounted on the bridge adjacent to a walk way along the bridge shall be completely screened from the walkway.

35.3.3 Collector Assembly

Collector assembly shall be rigidly mounted on the trolley and shall be provided with reasonable accessibility to all parts for maintenance purpose.

35.4 Earthing

35.4.1 General

The crane structure, motor frames, and metal cases of all electrical equipment including metal conduit or cable guards shall be effectively connected to earth complying with *Indian Electricity Rules, 1956* (see IS 3043). Preferably a ring earthing system to be provided on the crane. Each and every electrical equipment shall be connected to this earthing ring at least at two points. A flexible metallic tube or duct may not form an effective earth connection. The crane wheels shall not be used as means of earthing. Where the crane is connected to the supply by flexible cord or flexible cable, the crane shall be connected to earth by means of a separate earthing conductor enclosed with the current carrying conductors. Travelling cranes connected to the supply through collectors (minimum two numbers) shall be

effectively earthed through a fourth lead or through a set of collectors sliding on the gantry rail with reference to IS 3043. The purchaser shall arrange for the earthing of the gantry and/or the long travel earth conductor.

35.4.2 Control Circuit Earthing

One end of the secondary winding of control circuit transformer shall be earthed. One end of the coil of all relays and contactors shall be connected to earth side of the control circuit supply and this connection shall not be interrupted by any fuse or contact. In the case of d.c. control circuits one pole of the rectifier shall be earthed.

35.4.3 Magnet Earthing

The magnet frame shall be bonded to the trolley by the earth connection *via* the magnet lead, the magnet coupling, the magnet cable and an extra slip-ring on the cable drum.

35.5 Conductor Bars, Cable Reels and Flexible Cables

The following five important considerations shall be taken into account in dimensioning insulated wires or cables:

- Temperature rise in normal condition;
- Temperature rise in faulty operation and on short-circuit;

- c) Voltage drop;
- d) Cable grouping; and
- e) Motor full load current.

35.5.1 The following clauses in IS 16504 (Part 32) define the basic requirements:

- a) Flexible cable (*see* 13.7);
- b) Collector wires, collector bars and slip ring assemblies (*see* 13.8); and
- c) Connections to cranes and between moving parts of the crane (*see* 14.4.3).

According to IS 16504 (Part 32), wherever collector wires, conductor bars and slip-ring assemblies are installed as part of the protective bonding circuit, they shall not carry current in normal operation. Therefore, the protective conductor (PE) and the neutral conductor (N) shall each use a separate collector wire, collector bar or slip-ring. The continuity of the protective conductor circuit using sliding contacts shall be ensured by taking appropriate measures (for example, duplication of the current collector, continuity monitoring). The continuity of any protective bonding connection with sliding contacts shall be ensured for example, by duplication of the current collector (one set). Additionally, when sliding contacts are used to supply power to electronic drives, double collectors should be used to avoid noise and hardware failures which may occur, if a contact cuts off momentarily (2 sets of current collectors).

35.6 Calculation of Cross-Section of Conductors

35.6.1 These requirements apply both to the power supply to the crane and also to cabling within the crane. In general the selection of cable/conductors depend on the following:

- a) General operating conditions;
- b) Ambient air temperature;
- c) Methods of installation;
- d) Grouping; and
- e) Intermittent duty applications.

35.6.2 Co-ordination Between Conductors and Protective Devices

- a) In all cases, the following relationships shall exist:

$$I_b < I_n$$

$$I_b < I_z$$

Where,

- I_b = steady state design current;
- I_n = nominal current or current setting of the over current protective device, in A ; and
- I_z = effective current carrying capacity of a cable for continuous service under the particular installation conditions concerned in it, in A.

- b) Where the over current protective device is intended to provide overload protection, the following relationships shall exist:

$$I_b < I_n < I_z$$

$$I_2 < 1.45 \times I_z$$

Where,

I_2 is the minimum current, that when maintained for 1 h will cause the protective device to open the circuit, in A.

- c) Where the over current protective device is intended only to provide short circuit protection:

I_n may be greater than I_z , and

I_2 may be greater than $1.45 I_z$

However, it should be remembered that the higher I_n is in relation to I_z , the greater is the possibility of exceeding the ultimate short-circuit conductor temperature in the event of a short circuit. That is particularly true in the case of the smaller conductors ranging in size up to 16 mm².

35.6.3 Short Circuit Protection of Conductors

The conditions to be met for short circuit protection is:

$$C_s = \frac{\sqrt{t} I}{k}$$

Where,

C_s = conductor cross section, in mm²;

t = switch off time for protection against hazardous shock currents shall be decided based on tripping time of protective device selected;

I = effective short circuit current at fault point in amperes expressed for a.c. as the rms.; and

K = factor for conductor [Amp × sec / mm²] when insulated with the following material,

= 76 for PVC insulated aluminium conductors.

= 115 for PVC insulated copper conductors.

= 141 for Rubber insulated copper conductors.

= 132 for SiR insulated copper conductors.

= 143 for XLPE insulated copper conductors.

= 143 for EPR insulated copper conductors.

35.6.4 Calculation of the Cross-section in Relation to the Admissible Voltage Drop

The voltage drop must be considered, paying attention to the fluctuation and the voltage drop within the power supply. For very long supply lines, not only the resistive but also the inductive part of the supply impedance need to be taken into account. Drop due to reactance should also be checked. The cross-section of the conductors should be determined by taking

into account the mechanical strength required and the electrical load to be carried. Looping cable may be provided in parallel after checking the limit of voltage drop. When calculating the voltage drop, the most unfavourable position of the hoisting appliance in relation to the supply point must be considered.

The voltage drop shall be limited to 3 percent on DSL and 2 percent on the crane (from current collector to motor terminals). The conductor size and/or number of feed points should be increased or even booster cables should be used in parallel to runway conductors in case the voltage drop is exceeding the limit value.

Unless otherwise specified the maximum current density shall not exceed 0.42 A/mm² for rolled steel sections. The size of shrouded conductor, copper / aluminum headed conductor/GI conductor type DSL, the current rating as per manufacturer shall be followed.

35.6.5 For a three phase power supply, the required minimum cross-section (C_{SI}) of conductor can be calculated with the formula:

$$C_{SI} = \frac{\sqrt{3} \times I \times I_{tot} \times \cos \phi \text{ mm}^2}{\Delta u \times K}$$

Where,

I = effective length of the line, in m;

I_{tot} = sum of the above calculated (I_D and I_N) currents, in A;

Δu = admissible voltage drop, in V;

k = electric conductivity, in [$\Omega \times \text{mm}^2 \times \text{m}^{-1}$]⁻¹; and

$\cos \phi$ = power factor.

Calculation for voltage drop (for reference purpose):

$$\Delta u = \sqrt{3} \times I_{tot} \times I \times Z$$

Where,

I_{tot} = Net current load on DSL,

I = Effective length depending upon number and arrangement of feed points,

Z = Impedance = ($R \cos \phi + X \sin \phi$)(Ω/m),

R = resistance of the DSL conductor, and

X = Impedence of the DSL conductor.

35.6.6 Calculation of the Minimum Cross-section in Relation to the Thermal Capacity of the Conductors

When calculating the cross-section for the conductor bar, which supplies several hoisting appliances, the actual simultaneous operation of the drive motors must be taken into account.

The maximum allowed conductor temperature shall not be exceeded during normal operation. Conductor cross-section should be selected according to manufacturers' specifications.

NOTES:

1) In this clause, the rated current (I_N) should be considered not necessarily to mean the nameplate current of the motor but the current drawn by the motor at full rated load.

2) In case number of motors (n) > 1 are driven in parallel, consider: $I_N = n \times I_N$ (I_N = current drawn by the motor at full load).

3) In case two or more hoisting appliances are working together, they should be handled as one by using the sum current of each joint motion.

4) In case the power supply also feeds other (continuous) loads such as lighting, hydraulic pumps, lifting magnets, AC in e-room or other cranes, the current drawn by these devices need to be taken into account.

36 CABLES AND CONDUCTORS

36.1 General

Cables used for crane wiring shall comply with relevant Indian Standard. Unless otherwise agreed, only copper or aluminum cables shall be used for power wiring and only copper cables shall be used for control wiring. Single strand cables shall not be used where cable cross sectional area is more than 6 mm². Festoon or rubber cable with low capacitance values are recommended for cranes using ac VFD.

36.2 Minimum Size

While selecting cables consideration shall be given to factors like ambient temperature, grouping and disposition of cables, and the limitation of the voltage drop. The cables selection, testing shall be as per IS 694, IS 1554 (Part 1 and Part 2), IS 9968 (Part 1 and Part 2) and IS 7098 (Part 1).

Conductors for power wiring/control circuits to electric motors shall have a sectional area not less than the values given below of copper or equivalent material:

- [2.5 mm² for Power] and [1.5 mm² for control wire] should be up to M5 class.
- [4.0 mm² for Power] and [2.5 mm² for control wire] should be M6 class and above.
- For instrumentation cables shall be minimum 0.75 mm².

36.3 Protection

All cables shall be adequately protected against mechanical damages as given below:

- By running in conduits complying with relevant Indian Standards, trunking or on trays with top cover;
- By being clipped to the crane structure in a position where they are protected from mechanical damage; and
- By being of armoured construction.

If cables are drawn into a steel tube, the tube shall be medium gauge welded or solid drawn or screw jointed.

For outdoor cranes except where flexible unarmoured cables are essential, cables shall be either armoured or enclosed throughout their length in galvanized trunking or conduit. Taped and braided varnished cambric insulated cables shall not be used for outdoor cranes.

36.4 Current Rating

The current rating of the cable given in the relevant Indian standard / declared by cable manufacturer is for continuous duty. As the cranes are operating with intermittent duty motors, the continuous rating of cable shall be up-rated by intermittent duty factor.

The operative rating of the cable shall be computed giving due consideration of ambient temperature, grouping and disposition of cable and intermittent duty factor.

$$I_{\text{required}} = I_{\text{equipment}} / (C_1 \times C_2 \times C_3)$$

Where,

C_1 = Ambient temperature correction factor (recommended by cable manufacturer);

C_2 = Group rating factor (recommended by cable manufacturer); and

C_3 = $10/\sqrt{C_{DF}}$ for intermittent duty rated motor (25 percent, 40 percent, 60 percent etc.)
 = 1.7 for 1/2 h rated motor
 = 1.4 for 1 h rated motor

36.5 Installation

36.5.1 The cable and wiring system for each motion shall be independent and common return shall be avoided. Main cables and control cables shall be effectively separated wherever possible. Cables shall be adequately secured to the main structure of the crane having due regard for the weight of the cable and the possibility of vibration. Cable runs shall not be installed in a place where they will impede the crane driver's view or hamper the movement of persons on the crane. The cables shall be placed so that they are easily accessible. Due consideration shall be given during the design of the crane to make adequate provision for cable runs and to avoid cable runs in locations where mechanical damage or high temperatures are likely to be experienced. The segregation of power and control cables shall be made as far as possible depending upon the space available on the crane and keeping or maintenance point of view.

36.5.2 Where there is incidence of direct radiation of heat, the cables shall be protected by metallic shield. Where mineral insulated metal cables are subjected to the effects of high transient voltage they shall be suitably protected by the use of surge limiting devices. Cables remaining alive, when main isolator is opened, shall be separately installed and adequately protected. Adequate precaution shall be taken to prevent the

ingress or collection of water or oil in any part of a conduit or trunking system. For three phase a.c. power cables, if single core cables are used due to size limitations, efforts shall be made to lay the cables in trefoil formation.

36.6 Termination

Where trunking is used it shall extend into the electrical compartment or enclosed units. It shall be terminated as close as practicable to motors, collector gears and controllers. Junction boxes shall be rigidly fixed to the crane structure close to the end of the trunking. Conducting systems shall be continuous to switch boxes and conduit outlets. Cable tails shall be adequately insulated and mechanically protected.

37 ELECTRICAL PROTECTIVE AND SAFETY EQUIPMENT

37.1 Protective Equipment

37.1.1 General

Suitably located efficient means shall be provided to protect every part of a system from excess current and voltage to prevent danger or damage. Enclosures having minimum degree of protection IP 52 (except for inside e-room panels with minimum IP 42 enclosure or IP 00 open execution with protective cover, hand rail to prevent accidental contact) shall be provided for all electrical equipment except for motors, transformers and resistors.

37.1.2 Main Isolating Switches

37.1.2.1 Main switches used for isolating shall comply as per relevant Indian Standard. The main metal-clad isolating switch shall be provided on the crane bridge in an accessible position and connected directly to the long-travel collectors or terminal box in case flexible cables are used. The switch shall be located as close as possible to the long-travel collectors or terminal box, unless its position be otherwise specified. On fixed cabin cranes (see Fig. 9), it shall isolate all circuits, except the crane lighting circuits, warning lighting circuits, communication circuits; and in a.c. cranes, the circuit of the transformer supplying the portable lighting socket outlets. On moving cabin cranes, it shall isolate all circuits except bridge lighting circuits, warning lighting circuits and in ac cranes the circuit of the transformer supplying the portable lighting outlets. This isolating switch shall be unfused/MCCB/ACB/Isolator.

37.1.2.2 On moving cabin cranes (see Fig. 10) an additional main unfused metal-clad isolating switch shall be provided on the cabin structure in an accessible position outside the crane cabin and connected directly to the cross travel collectors or terminal box in case flexible cables are used. The switch shall be located as close as possible to the cross-travel collectors, unless

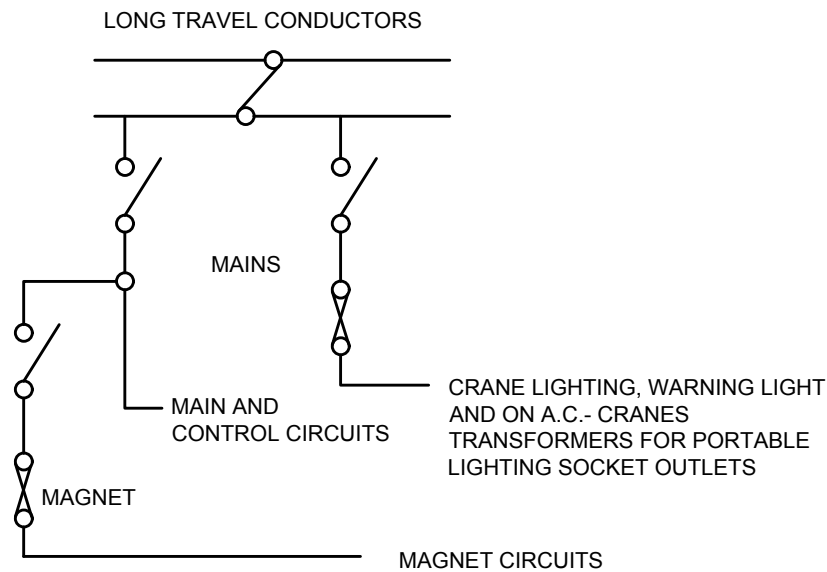


FIG. 9 MAIN ISOLATING SWITCHES AND FUSES REQUIRED FOR FIXED-CABIN CRANE

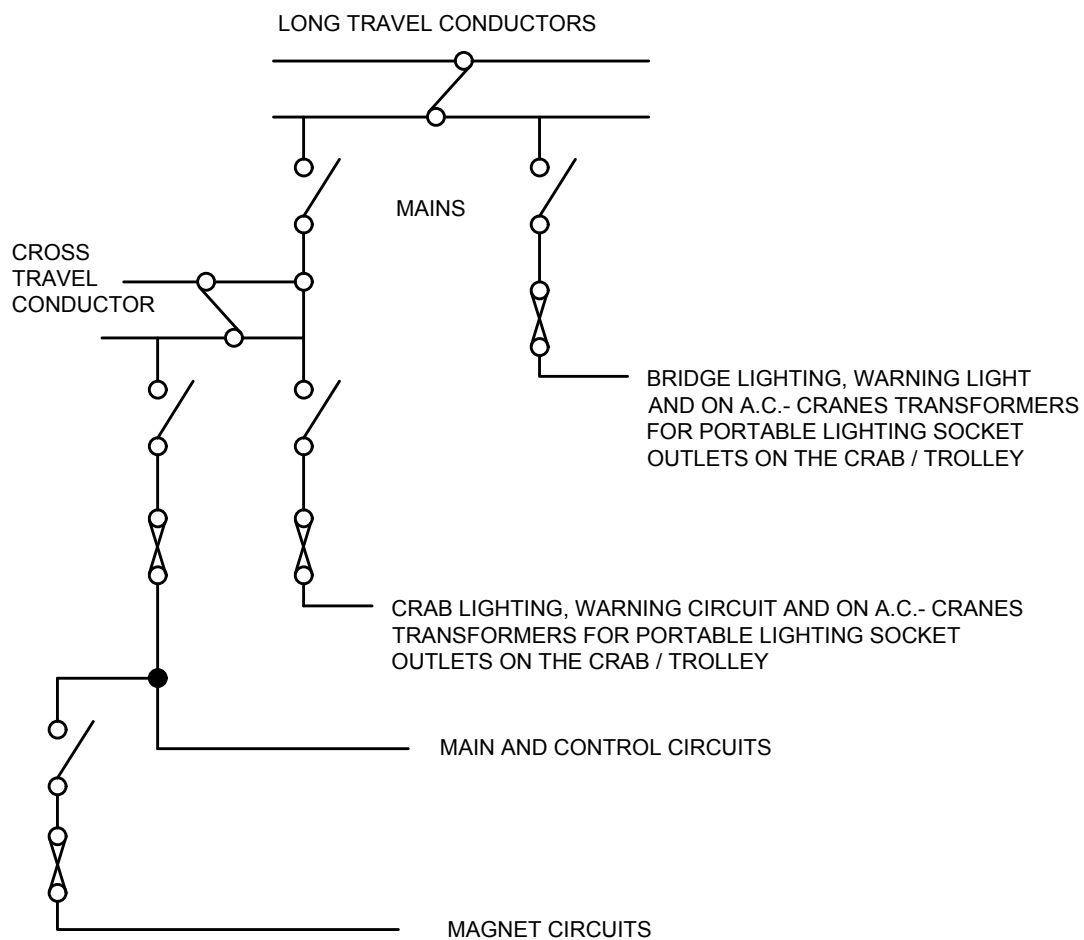


FIG. 10 MAIN ISOLATING SWITCHES AND FUSES REQUIRED FOR MOVING-CABIN CRANE

its position be otherwise specified. It shall isolate all circuits, except the trolley lighting circuits, circuits arranged to operate warning devices and on ac cranes the circuit to the transformer for the portable lighting socket outlets on the trolley. Alternatively, subject switch may be avoided by providing additional emergency stop push buttons on the trolley and cabin so that crane main contactor can be switched off during emergency. The selection, maintenance and installation shall be as per IS 10118 (Part 1 to Part 4). Each of the above main isolating switches shall be rated to carry at least 150 percent of the combined full-loads currents of the two motions of the crane using the largest power (kW) working together with auxiliary loads such as lifting magnets and shall be provided with a means for locking it in the 'OFF' position of the switch. The switch cover shall be interlocked with the operating handle, so that it may not be removed or opened when the switch is closed.

37.1.2.3 Live terminals inside the switch shall be shielded to prevent accidental contact. A pair of neon type pilot lamps or other device in duplicate, indicating when the supply to the crane control circuits is live, shall be provided in a position visible to the driver from his normal working position. If specified, the main isolating switch on the bridge shall be fitted with a pair of auxiliary contacts which will be closed when the main switch is open and *vice-versa*, to operate the crane warning lights

NOTE — Instead of fuse and isolator, MCB/MCCB/ACB may also be used

37.2 Electrical Protective Device

37.2.1 General

If electrically operated contactor/ VFD is used for control of all crane motions, the protective equipment shall be in accordance with either:

- a) *Scheme A* — Each motion has separate protection.

For conventional crane control system, electronic motor protection relays with instantaneous over-current release and inverse time overload release shall be provided. Manual reset provision shall be considered.

For cranes with VFD control, the in-built overload protection (settable) of the drive shall be used for protection of the motor in case of single motor drive. However, in case of multi motor drive, individual motor protection thermal overload relay /MPCB shall be used.

For cranes with VFD and common DC Bus configuration, isolation between the bus and inverter shall be provided.

- b) *Scheme B* — An overload condition of any motion trips off the supply of respective motion.

If drum controllers or master controllers are used for the control of all motions, the protective equipment shall

comply with scheme B. Also it is more often required that in master controller operated crane, overload of any motion should not trip the complete crane circuit, but should trip the individual circuit. In general, overload protection shall be of electromagnetic / electronic type with time delay.

Operation of any of the above protective devices shall automatically apply the electro-mechanical brakes on the relevant motion. If other systems of control or mixed systems are specified, the protective equipment shall be in accordance with the recommendations of the control gear manufacturer. An indelible circuit diagram of the protective equipment shall be provided in the electrical equipment compartment.

37.2.2 Protective Device Common to all Motions

Protective devices common to all motions shall have all necessary incoming and outgoing feeders along with minimum equipment for protection.

- a) Incoming feeder shall have manually operated SFU/MCCB/ACB and electromagnetically operated contactors.
- b) MCCB/ACB shall have short circuit and overload protection.
- c) The current rating of SFU/MCCB/ACB and contactors shall be at least the combined full load current of motors (at mechanical kW) for any two motions having largest power operating simultaneously and auxiliary load.
- d) If required current rating is very high and single contactor can not handle the load, motorized
- e) ACB in place of SFU/MCCB/ACB and contactor with remote operation facility may be provided. Motorised ACB shall have short circuit, overload and shunt trip facility.
- f) The outgoing feeder to all motion control circuit shall be provided with adequate short circuit protection., there will be HRC fuses or MCCB HRC fuses/MCCB/ACB suitably in each isolating position. For conventional crane control, HRC fuses may lead to single phasing; therefore MCCB/ACB shall be provided in each isolating position. However cranes with a.c. VFD control, semiconductor fuses with switch isolators can be provided at the converter and inverter inputs. The circuit breaker or main line contactor should not be rated to carry magnet full load current as magnet supply is taken before the circuit breaker/ main line contactor. The breaker shall have adequate rupturing capacity to withstand and clear fault current of the system. If specified a suitable control circuit may be provided for this circuit-breaker to prevent it from being closed when the main contactor of a particular motion has failed to open, although the corresponding controller has been brought to its 'zero' position.

37.2.3 *Ac Instantaneous Release Single Pole over Load: Protective Device for Individual Motions*

Any motor having its power less than one-third that of the largest motor and served by the same common overload release, shall be protected by a separate overload release. However, normally instantaneous release of overload relays are not used for individual motion and circuit breaker is tripped by its own overload. In crane with circuit breaker overload protection is provided by circuit breaker. The minimum provision for over current protection shall be as given below:

- One instantaneous release in a common line feeding all motions set to trip the main contactors or circuit breakers instantaneously when the current rises to 250 percent of the value specified above; and
- One inverse time-lag release in each other line feeding each motion, set to trip the respective motion when carrying 200 percent of the full load current of the line, after a time-lag of approximately 10 s.

It shall not be possible to reinstate the current supply to the common main contactor closing coils, or complete the under voltage circuit of the circuit breakers until the master controllers for all motions are returned to the 'off' position.

37.2.4 *Protective Devices for Motor Circuits*

The number of overload devices and their position shall normally be in accordance with the arrangements shown in Table 13. If specified by the purchaser, other arrangements giving protection not less than any of these shall be considered as complying with the specification.

Table 13 Normal Requirements for Number of Protective Devices for Circuit

(Clause 37.2.4)

d.c. Supply		3-phase a.c. supply
No line earthed	One line earthed	
2 per motion in separate lines	1 per motion connected in the non-earthed line.	3 per motion in separate lines

38 CONTACTORS

Reversing power contactors shall be interlocked, preferably mechanically as well as electrically so that only one directional contactor can be in the closed position.

39 CONTROL SWITCH FUSE

Operating coil circuit of the main contactor or control contactor in case of cranes with circuit breaker. A double pole control switch fuse/MCB shall be connected in the

operating coil circuit of the contactor. Miniature circuit breaker as an alternative to control switch fuse may also be used.

40 EMERGENCY SWITCHES

A mushroom head push button (with rotate to release facility) or a prominent switch for emergency stop shall be provided at each control facility to switch 'off' the total crane supply or to de-energize the main contactor common to all the motion drives. In the case of d.c. cranes, rheostat braking shall be applied to the hoist motions. When any circuit breaking device is open no main pole on the nominally dead side shall be made alive by a parallel circuit in emergency. The emergency switch shall be so located as to be readily available for prompt use by the operator in case of emergency. If specified by the purchaser or when the crane span is larger than 20 m, the number of emergency stops shall be more than one. A reset button shall be provided, if required by the purchaser. The emergency stop push-buttons or switches shall be connected in the operating coil circuit in the case of a contactor and in the under voltage release circuit in the case of a circuit breaker.

41 OFF-POSITION INTERLOCKING

Electrical interlocking shall be provided to prevent inadvertent starting of the motions, in the case when power is lost, without the controller being brought to the 'off' position on restoration of the supply.

42 PILOT LAMP

A red pilot lamp (LED type) shall be connected to indicate that the crane is ready for operations and it shall be so located that it is visible to the operator. The pilot lamp shall be connected so that it indicates whether the control supply is ON or OFF or the contactor is CLOSED or OPEN.

43 MAIN FEATURE OF BUILT-IN CRANE WEIGHING SYSTEM IF SPECIFIED

- Overall accuracy of the system shall be ± 3.0 percent or better;
- The system shall have the provision of tripping the circuit in case of overloading the cranes and should serve on an additional overload safety device; and
- Load display unit shall be provided in the operator cabin and crane girder

44 AUXILIARY SUPPLY

Auxiliary switches used for isolating shall comply with the relevant Indian Standards. If specified, an isolating switch shall be provided to isolate all supply lines to the main circuits of each motion. If specified single pole isolating switch with HRC fuse/MCB shall be provided on each motion panel. MCB/MCCB shall be provided

to isolate all supply lines to each of the following distribution boards or circuits where they exist.

44.1 Fixed Cabin Cranes

- a) Distribution board for all crane lighting circuits including warning lighting circuits,
- b) Distribution board for auxiliary circuits other than lighting circuits, and
- c) Magnet circuits.

44.2 Moving Cabin Cranes

- a) board for bridge lighting circuits including warning lighting circuits,
- b) Distribution board for all trolley lighting circuits,
- c) Distribution board of boards for auxiliary circuits other than lighting circuits, and
- d) Magnet circuits.

44.2.1 In fixed cabin cranes, the crane lighting circuit isolating switch shall be connected directly to the long travel collectors and located in the immediate vicinity of the main isolating switch on the bridge. In moving cabin cranes, the bridge lighting circuit isolating switch shall be connected directly to the live side of the main isolating switch with cables as short as possible. The switch shall be located on the bridge in the immediate vicinity of the main isolating switch. The trolley lighting circuit isolating switch shall be connected directly to the cross-travel collectors and located in the immediate vicinity of the main isolating switch on the crab. Molded case circuit breaker can be used as alternate to the switches and fuses, where ever is possible in the power circuit

45 DISTRIBUTION BOARD

Metal clad distribution boards incorporating adequate protection in all lines, except those directly connected to earth shall be provided as detailed below to feed the following auxiliary circuits where they exist. Distribution boards shall comply with relevant Indian Standards, except that semi-enclosed fuses shall not be used.

45.1 Fixed Cabin Cranes

45.1.1 *One Distribution Board for Crane Lighting Circuits*

- a) Cabin service and maintenance lighting;
- b) Cabin and bridge approaches and electrical equipment compartment lighting;
- c) Warning lights;
- d) In a.c. crane, the step down transformer supplying the socket outlets and walkway, and bridge lighting for illuminating the floor area; and
- e) One distribution board for cabin heating circuits, fan and air conditioning circuits, if provided.

45.2 Moving Cabin Cranes

- a) *One Distribution Board for Bridge Lighting Circuits* — Warning or signal lights; in ac cranes, the step down transformer supplying the bridge socket outlets, and walkways and bridge lighting.
- b) *One Distribution Board for Trolley Lighting Circuits* — Cabin service and maintenance lighting; cabin and bridge approaches and electrical equipment lighting and in ac cranes, the step-down transformer supplying the trolley socket outlets.
- c) One distribution board for cabin heating circuits, fan and air-conditioning circuits.

46 AUXILIARY SWITCHES OTHER THAN ISOLATION SWITCHES

46.1 Each auxiliary circuit shall be provided with a totally enclosed lighting switch component complying with relevant Indian Standard. These auxiliary switches shall be located as follows:

- a) For the equipment in the cab, such as, fans and air-conditioners (in cabin or e-room);
- b) For the electrical compartment lighting, at the door of the compartment;
- c) For the cabin approaches, bridge approaches, and bridge walkway lighting such that an operator can illuminate the approaches or walkways without traversing them;
- d) For the bridge lights on the crane bridge, at the crane entrance platform in fixed-cabin cranes and on the bridge in moving cabin cranes; and
- e) Non-fusible double pole emergency switches should be connected in series for opening the circuit breaker or main contactors on the protective panel.

46.2 Switches mentioned at **46.1 e)**, when 'OFF' will open both the main lines of the protective panel control circuit and will be located at the following places one in driver's cabin within the easy reach of the driver and one on each of the landing corners of the end carriages to be easily accessible to a person when boarding the crane or getting down from it. Additional switches shall be provided, if found necessary and when asked for.

47 IDENTIFICATION OF CIRCUITS

All switches and fuses shall be adequately labelled to facilitate the identification of the circuits. All panels, controller and resistors are to be properly marked for each motion. All main and control wires shall be ferruled at both ends, as per drawing for quick identification. All elements of the controller and panels are to be clearly marked by furnishing functional nomenclature at the devices. All equipment terminals shall be numbered and tagged.

48 DISPOSITION AND HOUSING OF ELECTRICAL EQUIPMENT

48.1 Electrical Equipment other than Resistor Assemblies

If electrical equipment is mounted in the open, it shall be of the enclosed type in weatherproof enclosure with provision for easy access to the parts inside.

48.1.1 Control panels and other electrical equipment should be so located that there is no chance for oil from the gear boxes, to drip on them.

48.1.2 The compartment or units shall neither impede the maintenance of the long-travel drives, nor be mounted on the bridge platform occupied by the cross-travel collector gear. The thoroughfare between the different parts of the crane or between any portion of the crane and the exit platform shall not entail passage through the compartment or be impeded by any control unit.

48.1.3 Control panels or units shall be so spaced that efficient maintenance may be performed, and shall withstand the mechanical forces imposed by the crane under service conditions.

48.1.4 The compartment shall be constructed of steel sections and plates, or other fireproof material of adequate mechanical strength. It shall be drip proof, adequately ventilated and lit, and in addition for outdoor cranes, weatherproof. If windows are provided, wired or toughened glass shall be used and it shall be possible to clean all glass surfaces without danger.

48.2 Resistor Assemblies

Resistor assemblies shall be so mounted as to ensure an adequate flow of cooling air and shall be mounted outside the main contactor compartment.

48.2.1 Resistor assemblies shall not impede the maintenance of the long-travel drives or access to the platforms of the crane, and shall be arranged so that efficient maintenance may be performed on each unit.

48.2.2 Resistor assemblies for each motion shall be stacked separately for the facility of inspection, maintenance and safety.

49 SAFETY FEATURES

49.1 Motor Over Speed Protection

All electronically controlled hoisting motions shall be equipped with over-speed protection. The over-speed protection shall prevent:

- a) uncontrolled and unintentional motions, and
- b) all parts of the mechanism from reaching its mechanical limit speed.

The trigger limit of the over-speed protection shall be set so that the mechanical brake is capable to stop the motion safely in all conditions. In general, the trigger limit should not exceed 1.05 to 1.1 times the specified speed at nominal load. For over speed sensing in case of non-hot metal handling cranes without load free fall arresting protection, the speed mismatch obtained from encoder feedback shall be adequate. However, in case of hot metal handling, separate over speed sensor like centrifugal switch/electronic over speed switch/proximity type over speed sensor, shall be provided to avoid free fall of the load. The speed switch can either be attached to the encoder mounted on the motor or at the hoisting drum. The emergency stopping with any possible speed and load combination shall not cause any hazard including the cases where the drive is intended to operate above the nominal speed.

49.2 Devices for Switching off for Prevention of Un-Expected Start Up

Devices for switching off for the prevention of unexpected start up shall be provided. The main incoming switch (crane-disconnector) fulfils that function for the complete crane. Where it is necessary to work on individual parts of a crane motion, additional disconnecting device shall be provided for each part requiring separate disconnection. Disconnectors, withdrawable fuse links, contactors can be used as hardware. Alternatively this protection can be provided by VFDs, in accordance with of IS 16504 (Part 32), if the discharge of stored energy would significantly restrict the availability of a machine, additional devices must be installed to reliably buffer the remaining energy. For instance, this involves a multi-motor drive with inverters connected to a common d.c. link. In this case, suitable resources must ensure that the "stored energy", that is the energy stored in the d.c. link capacitors of the individual inverters, is reliably buffered with the d.c. link voltage still available.

49.3 Limit Switch

Generally except the ultimate hoist limit switch, all other limit switches trip individual motions, when cranes are operated using VFD.

49.3.1 Limit Switches in Hoist Motion

49.3.1.1 Cranes with d.c. series motors

The final switches to be provided in the power circuit shall be of self-resetting type and shall initiate dynamic braking when tripped. If specified by the user, provisions shall be made in the control circuit to have an audio-visual annunciation to indicate that the final limit switch has operated.

49.3.1.2 Cranes with a.c.motors

- a) Final limit switch should trip the main contactor supplying power to all drive panels and shall be of manual reset type. Provision shall be made to by-pass the limit switch temporarily for emergency lowering of hot metal. While by-passing only lowering motion shall be possible;
- b) In case where final limit switch is used in the power circuit the same may be of manual or self-resetting type. If self-resetting type is used, there shall be a provision for audio-visual annunciation to indicate its operation, if specified by the user;
- c) If the ultimate limit switch is shunt-connected it shall control the protective panel circuit breaking device. No two-shunt limit switches shall control the same circuit-breaking device; and
- d) If occasional abnormally high lifts are required, arrangements may be made for by passing the first limit switch. Under such condition, hoisting should be possible at slow speed only when by passing button is kept pressed.

49.3.2 Track Limit Switches

If specified, one or more track switches shall be fitted to the bridge to give warning of approach to a danger area. They shall be operated by suitable devices to be fixed to the crane gantry as required and shall either operate an audible warning signal or trip the main circuit-breaker on the crane, as specified in 37. Track switches shall be so arranged that they can be readily tested. Strikers shall be so arranged as to prevent damage of the limit switch on over travel due to impact.

49.3.3 Proximity Sensing / Anti-Collision Devices

If specified, one or more devices shall be fitted to the bridge of the crane to give warning of the approach to danger, or another crane. Anti-collision devices are relevant to safety. Their failure will result in high impact forces, which may cause damage to the loads transported or to system components, or personal injuries. Strict requirements are to be met with respect to reliability and safe functioning of anti-collision devices. They shall be failsafe under the specified environmental conditions (such as, temperature limits, dust, alternating electromagnetic fields). Note that 'emergency stop functions' of electrical limit switches can be realized using mechanically actuated switches which function according to the positive-opening principle. Non-contact or proximity limit switch systems only afford the desired operational reliability, if combined with a safe circuit including self-monitoring and plausibility check. Where the 'emergency stop function' is undesirable, monitoring devices will be required for clear and unambiguous indication of any fault. UPS may also be provided for the control system if required by purchaser.

49.4 Safeguarding Motors against Overheating

Motor overload protection shall fulfill the requirements of relevant Indian Standards. Protection methods based on actual temperature measurement of the motor are preferred. The overload protection can also be implemented by electronic devices, which may be either separate devices or integrated in the control or drive unit. Motor thermistor inside motor winding with thermistor relay in control panel may be provided.

49.5 Over-Current Protection of Conductors

All conductors are required to be protected against over-current by protective devices inserted in all live conductors so that any short-circuit current flowing in the cable is interrupted before the conductor has reached the maximum allowable temperature as per the relevant Indian standards. For selection of the correct protective device for switching off in case of a short circuit (*see 37*). The cross-section of a conductor should be determined according to the current intensity to which it is subject during both normal running of the motor and starting-up or electrical braking. Whether the loads (motors) are overload protected or not, all wires should be safeguarded against any over current, which could result from a short circuit or faulty insulation. The protective device shall be rated for the anticipated short-circuit currents.

49.6 Safeguarding Against Absence or Inversion of Phases

Where an incorrect phase sequence of the supply voltage can cause a hazardous condition or damage to the hoisting machine, protection should be provided. If the absence of phases may occasion a danger, the appropriate safety measures must be taken.

49.7 Action of Safety Devices

When several motors drive the same motion, the action of a safety device should stop all of the motors for this movement. After a safety device has been activated, it should be possible for the equipment to be started up again only manually.

49.8 Protection Against the Effects of Lightning

For very tall pieces of hoisting equipment which are erected in particularly exposed locations, the effects of lightning must be considered on:

- a) pieces of vulnerable structure (for example, jib support cable); and
- b) anti-friction bearings or runners which form a link between large parts of the frame (for example, slewing rings, travel runner).

When necessary, safeguarding against the effects of lightning should be carried out.

For the safety of personnel, it is recommended that the runner rails for the lifting equipment are earthed.

49.9 Electrical Safety Features

49.9.1 Wiring of the cranes where high ambient temperature and radiant heat from an open-top ladle are exposed shall be with high temperature insulation cables.

49.9.2 Motors and controls shall be de-rated based on their ambient temperature.

A crane disconnecting means, either a current rated circuit breaker or main isolator switch, lockable in the open position shall be provided in the lead from the run way contact conductors or other power supply.

Each motor shall be provided with overload and short circuit protection.

49.9.3 Control circuits shall be protected with over load protection.

Under voltage protection shall be provided as a function of each motor controller, or an enclosed protective panel, or a magnetic main line contactor, or a manual magnetic disconnect switch, and on automatic cranes, all motions shall be disconnected, if the crane does not operate in accordance with automatic sequence of operations.

50 DESIGN AND SELECTION OF MOTORS

50.1 General

The selection and testing of the motors shall be as per IEC 60034-25 or IS 12615 or any other equivalent Indian standard. The following details needs to be checked by the crane designer while selecting the motors for the corresponding motions:

- Required power (thermal rating of the motor calculated as per 5.8 of FEM 1.001);
- Required maximum rated torque and maximum acceleration torque (considering motor and load GD 2 values);
- Cyclic duration factor;
- Number of cycles/h;
- Type of control (includes type of electrical braking also);

- Speed regulation;
- Type of power system;
- Ambient temperature;
- Altitude; and
- Suitability of motor for VFD operation.

NOTES:

1) Derating factor (if any) on account of losses due to harmonics shall be declared by the manufacturer.

2) Highest calculated ratings of the motor as per service factor formula or thermal adequacy rating shall be the basis of the selection

50.2 Sizing of a.c. Motors for Hoist Motion

For hoisting motor the power required shall be equal to or greater than that computed from the following:

$$P_{\text{mech}} (\text{kW}) = M \times V / (6.12 \times E)$$

$$P_{\text{comp}} (\text{kW}) = P_{\text{mech}} \times S / C_{\text{amb}}$$

Where,

P_{comp} kW = power rating of motors as in table given below table;

M = mass of the rated load on the hook plus weight of the hook block and the wire ropes, in tonnes;

V = Specified hoisting speed, in m/min or actual speed based on gear box ratio whichever is higher;

E = Combined efficiency of gears and sheaves;

= $(0.93)^n \times (0.98)^m$ for sleeve bearings,

= $(0.95)^n \times (0.99)^m$ for anti-friction bearings (for spur and helical gears;

Efficiency to be taken as 0.95 per reduction),

= $(0.985)^n \times (0.99)^m$ for hardened profile ground and oil splashed lubricator;

n = number of pairs of gears;

m = total number of rotating sheaves passed over by each part of each moving rope attached to the drum; and

S = Service Factor

Values of Service Factor (S) for a.c.

No. of Round Trips/ percent Time Operation per Hour	Electrical Service Class	Mechanism Classification	Slip ring motor (Rheostatic / Thyristor Control) / Sq. Cage Motor with DOL Starter				Squirrel cage motor (VFD control)
			Hoist	Bridge Service Factor		Trolley service factor	Hoist, bridge and trolley service factors
				With Plugging	Without Plugging		
15 / 20	E1	M1-M2-M3	1.0	1.1	1.0	1.2	1.0
25 / 30	E2	M4-M5	1.0	1.2	1.1	1.3	1.0
35 / 40	E3	M6-	1.1	1.3	1.2	1.4	1.1
45 / 50	E4	M7-M8	1.2	1.4	1.3	1.5	1.2
45 / More than 50			1.2	1.5	1.4	1.5	1.2

Where,

P_{mech} = Mechanical power;

P_{comp} = Required motor power; and

C_{amb} = Derating/uprating factor for ambient temperature.

NOTES:

1) derating/uprating factor for ambient temperature higher or lower than design ambient of motor shall be as per motor manufacturer declaration for their standard crane duty motor rating.

2) Altitude variation factor shall be as per motor manufacturer.

50.2.1 For a.c. Slip Ring Type Hoist Motor

For an a.c. hoist motor, the specified full load hoist speed must be obtained at not more than rated torque, therefore, the calculated full load kW must be multiplied by:

$$\frac{(100 - \text{Rated slip percent})}{(100 - \text{Total ohms at full speed percent})}$$

Where sufficient information is not available values given in Table 14 for duty cycles, cyclic duration factor and starting class corresponding to mechanism class shall be used.

The values given are based on the following formula:

$$\text{Cyclic duration factor} = \frac{\text{Operating time} \times 100}{\text{Operating time} + \text{Idle time}}$$

50.2.2 The starting class (C) assumes numbers of complete starts (S), jogging operations (J) and electrical braking operations (B) as follows:

$$C = S + K_1 J + K_2 B$$

Where,

K_1 = 0.20 squirrel cage motor operated by VFD control

= 0.25 for slip ring motors.

= 0.5 for squirrel cage motors for DOL starting.

K_2 = 0.8 for slip ring motors.

= 0.50 squirrel cage motor operated by VFD control

= 3.0 for squirrel cage motors for DOL starting.

For computation of number of starts/hour can be done using number of operating cycles/hour and number of moves in each cycle for hoist and travel motion the hoisting cycle constitutes four motions:

- Full load hoisting,
- Full load lowering,
- No load hoisting, and
- No load lowering.

A cycle of a bridge or trolley consist of two moves, one loaded and one unloaded

Table 14 Recommended Cyclic Duration Factor and Starting Class

(Clauses 50.2.1, 50.3.2 and 50.5.8)

SI No.	Mechanism Class	Number of Operating Cycle / hour	Recommended Cyclic Duration Factor Percent	Starting Class (C) Equivalent Starts 1 h
(1)	(2)	(3)	(4)	(5)
i)	M1	Up to 5	25	90
ii)	M2	6 to 10	25	90
iii)	M3	11 to 15	25	150
iv)	M4	16 to 20	25	150
v)	M5	21 to 30	25/40	150/300
vi)	M6	31 to 40	40	300
vii)	M7	41 to 50	60	300/600
viii)	M8	51 to 60	60	300/600

50.3 a.c Motor for Crane Travel or Trolley Traverse

50.3.1 General

It is assumed that the drive mechanism from the motor to the track wheels will use enclosed gearings mounted on anti-friction bearings. The actual efficiency of the drive will be adopted in making calculations. Where actual efficiency values are not available the efficiency of the drive shall be taken in the range of 0.85 to 0.9.

For the track wheel with anti-friction bearings the rolling friction at these bearings plus the friction between the track wheels with an average drive efficiency of 0.875 shall give an overall friction factor of 8.0 kgf per tonne of the mass moved for calculation of the motor horse power or torque. In the case of wheels with the plain bearings an overall friction factor of 13.0 kgf per tonne of the mass moved may be used.

50.3.2 Sizing of a.c Motors for Crane Travel or Trolley Traverse

For bridge travel or trolley traverse, the power of the motor required shall not be less than that computed from the following:

a) For indoor cranes:

$$P_R (\text{kW}) = \frac{M \times V \times F}{6117}$$

$$P_A (\text{kW}) = \frac{M \times V}{6117} \times \frac{(1100 \times a)}{(981 \times N)}$$

$$P_{\text{mech}} (\text{kW}) = \frac{(P_R + P_A)}{T}$$

P_{comp} is computed power of motor

$$P_{\text{comp}} (\text{kW}) = P_{\text{mech}} \times S / C_{\text{amb}}$$

b) For outdoor cranes:

$$P_R (\text{kW}) = \frac{M \times V \times F}{6117}$$

$$P_A (\text{kW}) = \frac{M \times V}{6117} \times \frac{(1100 \times a)}{(981 \times N)}$$

$$P_{\text{wind}} (\text{kW}) = \frac{R_w \times V}{6117}$$

$$P_{\text{mech}} (\text{kW}) = \frac{(P_R + P_{\text{wind}} + P_A)}{T}$$

$$P_{\text{comp}} (\text{kW}) = P_{\text{mech}} \times S / C_{\text{amb}}$$

If travel resistance to wind is not specified, consider wind force (R_w) corresponding to 8 kgf/m² for sizing of motor.

If travel resistance to wind is specified, consider the same in the above calculation. The limiting value of working wind force (R_w) as per IS 807 is 25 kgf/m².

Where,

P_R = Running power;

P_A = Acceleration power;

P_{mech} = Average mechanical power;

P_{comp} = Required motor power;

P_{wind} = Power required to overcome wind force;

$R_w = W_8 \times \text{area exposed to wind, in m}^2$;

$= W_{25} \times \text{area exposed to wind, in m}^2$;

W_8 = Wind load 8 kgf/m²;

W_{25} = Wind load 25 kgf/m²;

kW = one hour power rating for d.c. motors and power rating minimum at (S3– 40 percent) cyclic duration factor for a.c. motor;

M = mass of crane or trolley plus mass of max rated load, in tonne;

V = Specified travel speed in m/min or actual speed based on gear box ratio whichever is higher;

N = mechanical efficiency of gearing. For spur and helical gears, efficiency to be taken as 0.95 per reduction. For hardened and ground gears, efficiency to be taken as 0.985 per reduction;

T = factor introduced by the permissible motor torque during acceleration, exceeding the motor-rated torque. As a general guidance value of T may be taken as 1.7 for motors having pull out torque of 275 percent full load torque for slip ring motor and 1.5 for motors having pull out torque of 225 percent of full load torque corresponding to P_{mech} for squirrel cage motor fed from VFD. Lower values of T should be taken for corresponding lower values of pull out torque.

= 1.7 for a.c. Slip Ring Induction motors

= 1.6 for a.c. motors, fed from DOL

= 1.5 for a.c. motors when operated from VFDs

F = overall friction factor

= 8 kgf per tonne for wheels on anti-friction bearings

= 13 kgf per tonne for wheels on plain bearings

R_w = load due to service wind acting horizontally as defined in 7.3.1 which can be obtained by multiplying the horizontal exposed area by the service wind by taking drag co-efficient into consideration;

a = average linear acceleration of the crane or the trolley in cm/s² till the mechanism reaches 90 percent of free running speed. For the values of average linear acceleration as given in 50.5.5; and

S = service factor aimed at providing adequate motor heat dissipation capacity as given in 50.5.2.

NOTES:

1) Duty cycle per hour (number of operating cycles per hour), recommended cyclic duration factors for the mechanism class can be taken from Table 14.

2) At free running speed, the acceleration becomes zero.

3) The gear reduction ratio actually used should be reasonably close to the ideal reduction ratio =

$$\frac{\text{Motor rev/min at free running}}{\text{Track wheel rev/min at specified free running speed}}$$

Track wheel rev/min at specified free running speed

4) In order to limit the acceleration to the specified value and also to take full advantage of the service factor the electrical control should be designed to suit the values of 'S' and 'T' actually adopted or values of 'S' and 'T' should be selected based on electrical controls to be provided.

5) Since the wheels must transmit all acceleration forces to the crane, to prevent wheel skidding due consideration should be given on percent driven wheels after acceleration rate has been fixed. The wheel skidding should be checked at no-load conditions considering 20 percent adhesion between wheel and rail.

6) The skewing force arising during the running of the crane needs to be considered by the designer while designing/configuring the electronics controls. This is usually a function of the ratio of span to the wheel base.

7) The gradients of the track and the necessary forces for CRD fed cranes has to be taken into consideration when designing the travel motor.

50.4 Sizing of d.c Motors for Hoist Motions**50.4.1 Direct Current Motors**

The motors shall be so selected that their one hour power rating is not less than that computed from the following formula:

$$P_{\text{mech}} \text{ (HP)} = M \times V / (4.56 \times E)$$

$$P_{\text{comp}} \text{ (HP)} = P_{\text{mech}} \times K$$

Where,

M = weight or the rated load on the hook plus weight of the hook block and the wire ropes, in tonnes;

V = specified hoisting speed, in m/min; and

E = combined efficiency of gears and sheaves,

= $(0.93)n \times (0.98)m$ for sleeve bearings

= $(0.95)n \times (0.99)m$ for anti-friction bearings

= $(0.985)n \times (0.99)m$ for hardened profile ground and oil splashed lubricator

n = numbers of pairs of gears;

m = total number of rotating sheaves between drum and equalizer passed over by each part of the moving rope attached to the drum; and

K = Service factor depending on the electrical service class of crane.

50.4.2 Recommended values of K for series motors operated at 230 volts as given below.

Values of Service Factor 'K' for Hoist Motor
(Series Motor)

Duty Cycle	Electrical Service Class	Service Factor K
Not more than 20 percent time ON and not more than 15 cycles per hour	1	0.75
21-30 percent time ON or 16-25 cycles per hour	2	0.75
31-40 percent time ON or 26-35 cycles per hour	3	0.82
41-50 percent time ON or 36-45 cycles per hour	4	0.96

50.4.3 For voltages other than 230 volts, use the one-hour ratings at the selected voltage, as established by the motor manufacturer.

50.4.4 For duty cycle of more than 50 percent time 'ON' or 45 cycles per hour, the requirements must be submitted to the motor manufacturer for selection of adequate ratings.

50.5 Sizing of d.c. Motors for Bridge Travel or Trolley Traverse

50.5.1 The selected motor shall have the one hour power rating which is not less than that computed from the following formula:

$$\text{Selected Power (HP)} = F \times M \times V \times S$$

Where,

F = a factor which includes for power to overcome friction, to give linear acceleration to the mass moved, and the angular acceleration to the motor armature and the rotating parts;

M = mass moved, in tonnes;

V = specified free running speed, in m/min; and

S = a service factor aimed at providing adequate motor heat dissipation capacity to cover for the severity of the expected duty cycle.

50.5.2 Recommended values for F and S are given in tables below.

Values of Friction Factor (F)

Acceleration Whilst on the Resistor cm/s^2	Track Wheels on Anti-friction Bearing	Track Wheels on Plain Bearing
15	0.002 5	0.003 3
30	0.003 5	0.004 4
45	0.004 3	0.005 4
60	0.005 1	0.006 3
75	0.005 8	0.007

Values of Service Factor (S) for d.c. Motor

No. of Round Trips/Percent Time Operation per Hour	Electrical Service Class	Mechanism Classification	DC Motor			
			(Resistance/Thyristor Control)			Trolley Service Factor
			Hoist	Bridge Service Factor		
With Plugging	Without Plugging					
15 / 20	E1	M1-M2-M3	1.0	1.1	1.0	1.2
25 / 30	E2	M4-M5	1.0	1.2	1.1	1.3
35 / 40	E3	M6-	1.1	1.3	1.2	1.4
45 / 50	E4	M7-M8	1.2	1.4	1.3	1.5

50.5.3 For other values of acceleration between two figures, intermediate values of K may be taken.

50.5.4 At crane or trolley free running speed, the acceleration becomes zero and hence the power to be furnished by the motor is:

a) *Case I* — Track wheels on anti-friction bearings,

$$\text{Required Power (HP)} = 8 \times M \times V/4562$$

$$\text{Required Power (HP)} = 0.00175 \times M \times V$$

b) *Case II* — Track wheels on plain bearings,

$$\text{Required Power (HP)} = 13 \times M \times V/4562$$

$$\text{Required Power (HP)} = 0.00285 \times M \times V$$

50.5.5 If the acceleration values are not specified by the user, this may be chosen corresponding to the speeds to be reached according to the three following working conditions:

- Appliances of low and moderate speed with a great length of travel;
- Appliances of moderate and high speed for normal applications; and
- High speed appliances with high acceleration.

The values of acceleration for the above three conditions are given below:

Acceleration Values 'a'

Speed to Be Reached M/Min	Acceleration in cm/s ² for Low and Moderate Speed with Long Travel	Acceleration in cm/s ² for Moderate and High Speed (Normal Application)	Acceleration in cm/s ² for High Speed With High Acceleration
240	—	50	67
190	—	44	58
150	—	39	52
120	22	35	47
100	19	32	43
60	15	25	33
40	12	19	—
25	10	16	—
15	8	—	—
10	7	—	—

50.5.6 Since the wheels must transmit all acceleration forces to the crane, to prevent wheel skidding due consideration should be given on percent driven wheels after acceleration rate has been fixed. The wheel skidding should be checked at no-load conditions

considering 20 percent adhesion between wheel and rail.

50.5.7 It is essential that the gear reduction ratio actually used be reasonably close to the ideal reduction ratio (motor speed when developing calculated free running power) / (track wheel speed to give specified running speed).

50.5.8 For limiting the acceleration to the specified value and also to take full advantage of the service factor actually used, it is essential that whilst the motor is on the resistor, the electrical control shall limit the average current to a value corresponding to 1.33 times the torque which the selected motor would furnish when developing power of K MV, that is, KMVS with S taken as unity.

NOTES:

1 Duty cycle, recommended cyclic duration factors and recommended starting class for the mechanism class can be taken from Table 14.

2 At free running speed the acceleration becomes zero.

3 The gear reduction ratio actually used should be reasonably close to the ideal reduction ratio:

$$= \frac{\text{Motor rev/min at free running}}{\text{Track wheel rev/give specified running speed}}$$

4 In order to limit the acceleration to the specified value and also to take full advantage of the service factor the electrical control should be designed to suit the values of 'S' and 'T' actually adopted or values of 'S' and 'T' should be selected based on electrical controls to be provided.

5 Since the wheels must transmit all acceleration forces to the crane, to prevent wheel skidding due consideration should be given on percent driven wheels after acceleration rate has been fixed. The wheel skidding should be checked at no-load conditions considering 20 percent adhesion between wheel and rail.

6 The skewing force arising during the running of the crane needs to be considered by the designer while designing / configuring the electronics controls. This is usually a function of the ratio of span to the wheel base.

7 The gradients of the track and the necessary forces for CRD fed cranes has to be taken into consideration when designing the travel motor.

8 The horizontal forces arising due to the swaying of the load also needs to be considered for designing of the motor especially for a high load inertia.

51 CYCLIC DURATION FACTOR AND NUMBER OF CYCLES PER HOUR

Table 15 indicates the number of cycles per hour and the cyclic duration factor for the vertical motions as a guideline.

51.1 Table 16 indicates the number of cycles per hour and the cyclic duration factor for the horizontal motions as a guideline.

Table 15 Number of Cycles per Hour and the Cyclic Duration Factor for the Vertical Motions
(Clause 51)

Sl No.	Type of Appliance		Particulars Concerning Nature of Use	Number of Cycles per Hour	Type of Mechanism ED Percent		
	Reference	Designation			Lifting	Derricking hinged boom	Derricking boom
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1	Hand-operated (non motorized) appliances	—	—	—	—	—
ii)	2	Erection cranes	—	2 - 25	25 - 40	—	—
iii)	3	Erection and dismantling cranes for power stations, machine shops, etc.	—	2 - 15	15 - 40	—	—
iv)	4	Stocking and reclaiming transporters	Hook duty	20 - 60	40	S2 (2) 15 - 30 min	—
v)	5	Stocking and reclaiming transporters	Grab or magnet	25 - 80	60 - 100	S (2) 15 - 30 min	—
vi)	6	Workshop cranes	Grab or magnet	10 - 50	25 - 40	—	—
vii)	7	Overhead traveling cranes, pigbraking cranes scrapyards cranes	—	40 - 120	40 - 100 60	—	—
viii)	8	Ladle cranes	—	3 - 10	40 - 60	—	—
ix)	11	Forge cranes	—	6	40	—	—
x)	12	a) Bridge cranes for unloading, bridge cranes for containers.	a) Hook or spread duty	20 - 60	40 - 60	S (2) 15 - 30 min	—
		b) other bridge cranes (with trolley and/or slewing	b) Hook duty	20 - 60	40 - 60	S (2) 15-30 min	—
xi)	13	Bridge cranes for unloading, bridge (with trolley and /or slewing jib crane)	Grab or magnet	20 - 80	40 - 100 60	S (2) 15 - 30 min	—
xii)	14	Drydock cranes, shipyard jib cranes, jib cranes for dismantling.	Hook duty	20 - 50	40	—	—

52 DESIGNING THE CRANE CONTROLS

The following crane control schemes are used in the steel mill depending on the type of motor:

- d.c. motor with thyristor based controls;
- a.c. slip ring motors with conventional controls using rotor resistances and plugging braking;
- a.c. Slip ring motors with thyristor based controls; and
- a.c. squirrel cage motors with VFDs.

53 CRANE CONTROLLING ARRANGEMENTS

53.1 General

The type of controls to be used shall be as agreed to between the manufacturer and the purchaser. Cranes having alternative control or brake circuit facilities shall

be provided with means to prevent operation from more than one facility at any one time.

NOTE — Main circuits are those which carry main motor or magnet current. Control circuits with brake circuit mechanism are those which are used for control equipment for main motor or magnet.

53.2 Controllers

Controllers shall be rated to comply with IS/IEC 60947-2, IS/IEC 60947-4-1. Controllers shall be suitably protected to prevent accidental contacts with the live parts. Controllers in 'off' position shall open all supply lines of the respective motors, unless otherwise agreed to, in which case a warning notice shall be fixed to the controllers. On or adjacent to each control device, there shall be a clear marking identifying the motion controlled and the direction of movement.

Table 16 Number of Cycles per Hour and the Cyclic Duration Factor for the Horizontal Motions
(Clause 51.1)

Sl No.	Type of Appliance		Particulars Concerning Nature of Use ¹⁾	Number of Cycles Per Hour	Type of Mechanism ED Percent		
	Reference	Designation			Rotation	Crab	Travel
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1	Hand-operated (non motorized) appliances	—	—	—	—	—
ii)	2	Erection cranes	—	2 - 25	25	25 - 40	25 - 40
iii)	3	Erection and dismantling cranes for power stations, machine shops, etc		2 - 15		25	25
iv)	4	Stocking and reclaiming transporters	Hook duty	20 - 60	15- 40	40 - 60	25 - 40
v)	5	Stocking and reclaiming transporters	Grab or magnet	25 - 60	40	60	15 - 40
vi)	6	Workshop cranes	—	10 - 50	—	25-40	25 - 40
vii)	7	Overhead traveling cranes, pigbraking cranes Scrapyard cranes	Grab or magnet	40 - 120		40 - 60	60 - 100
viii)	8	Ladle cranes	—	3 - 10	—	40 - 60	40 - 60
ix)	9	Soaking pit cranes		30 - 60	40	40 - 60	40 - 60
x)	10	Stripper cranes, open-health furnace-charging cranes	—	30 10		40 40	60 40
xi)	11	Forge cranes	—	6	100	25	25
xii)	12	a) Bridge cranes for unloading, bridge cranes for containers.	a) Hook or spread duty	20 - 60 20 - 60	15 - 40 25 - 40	40 - 60 40 - 60	15 - 40 25 - 40
		b) other bridge cranes (with trolley and/or slewing	b) Hook duty				
xiii)	13	Bridge cranes for unloading, bridge (with trolley and /or slewing jib crane)	Grab or magnet	20 - 80	40	40 - 100	15 - 60
iv)	14	Drydock cranes, shipyard jib cranes, jib cranes for dismantling	Hook duty	20 - 50	25	40	25 - 40
v)	15	Dockside cranes (slewing, on gantry, etc.), floating cranes and pontoon derricks	Hook duty	40 20	25 - 40	40	15 - 25
xvi)	16	Dockside cranes (slewing, on gantry, etc), floating cranes and pontoon derricks	Grab or magnet	25 - 60	40 - 60		25 - 40
xvii)	17	Floating cranes and pontoon derricks for very heavy loads (usually greater than 100)	—	2 - 10	15 - 40	—	—
xviii)	18	Deck cranes	Hook duty	30 - 60	40	—	—
xix)	19	Deck cranes	Grab or magnet	30 - 80	60		
xx)	20	Tower cranes	—	20	40 - 60	25	15 - 40
xxi)	21	Derricks	—	10	25	—	—
xxii)	22	Railway cranes allowed to run in train	—	10	25	—	—

¹⁾ This column comprises only some indicatory typical cases of utilization.

53.2.1 Control Equipment for d.c. Motors

Contactors, switches and allied electrical components shall be selected on the basis of calculated power (in kW) of the motor.

53.2.2 Control Equipment for a.c. Motors

The rating of the control gears, such as, switches, overloads etc, shall be selected according to the computed motor power without the service factor of the motion served and not on the motor power computed by the thermal requirements.

The contactors selected under **53.2** shall have the stipulated contact life as may be specified by the user.

53.3 Controllers Provided in the Cabin

All control handles and pedals shall be placed in convenient position to allow the driver ample room for operation and permit an unrestricted view of the load. They shall be so disposed that the contacts and terminal arrangements are readily accessible for inspection and maintenance purposes. The controls should be so arranged that the operator has an adequate view of the crane's working area. The control for hoisting appliances shall preferably be arranged on the right-hand side of the operator's seat.

53.3.1 Marking Direction of Operation of Controllers

Where practicable controller handles shall move in the direction of resultant load movement. Each controller shall be marked in a permanent manner to show the motion controlled and direction of movement. For vertical lever, handle operating hoist controllers, movement towards operator shall indicate hoisting and movement away from operator shall indicate lowering.

53.3.2 Notching

The notching for the controller handle in the 'off' position shall be more positive than the notching in other positions. The handle may be provided with a lock, latch, dead man or spring return feature, if specifically requested by the customer. The control lever shall be provided with stops and/or catches to ensure safety and facility of operation. A controller drum fitted with a star wheel shall be regarded as complying with the requirement.

53.3.3 Master Controller

Master controller operated cranes shall be provided with automatic control of acceleration. Accelerating torque/current peak shall be limited during controller handle movement from one notch to the other with due consideration to the pullout torque of the motor and number of rotor accelerating contactors shall be

selected accordingly. For master control operated cranes the control voltage preferably 110 a.c. and shall not exceed 240 for a.c. or d.c. supply. Typical location of various motion controller of the crane with respect to operator are given in Fig. 11 and Fig. 12.

53.4 Pendant Controllers

Cranes with pendant controls shall not have long travel speed in excess of 40 m/min. Pendant control may directly descend from the trolley or from the independently traveling trolley or from a convenient position on the crane bridge. Push-buttons or other switching devices, which automatically return to their 'off' position as soon as they are released, should be provided for the control of all motions by pendant control units. Housings of pendant control units should preferably be of fully insulating material or of material with protective insulation. Metal parts accessible from the outside, which pass through the insulation, should be separately earthed. The surface of the housing must be a vivid colour. For indoor operation, the degree of protection should be at least IP54, and for outdoor operation at least IP65. Pendant control units shall be suspended with a strain relief arrangement.

53.4.1 Pendant Switches

The pendant switches shall be capable of withstanding rough handling without being damaged and the cover shall be effectively secured. If control is from the floor, the electrical control circuit to the pendant shall be energized at not more than 110 V a.c. supply.

53.4.2 Pendant Control

On all pendant controlled cranes means shall be provided to prevent inadvertent operation from the floor while maintenance work is being carried out on the crane. An isolator fitted on the crane bridge, which can not be operated from the floor will comply with this requirement.

53.4.3 Pendant Control Station

If the control is by push buttons or switches, they shall automatically return to the 'off' position immediately after they are released. One lockable type push button shall be provided to switch off control power when the crane is not in use and if other means of switching off is not available.

53.4.4 Suspension of Pendant Switch

The weight of the pendant shall be supported independently of the electric cables by means of chain or wire rope. If the pendant enclosure is of metal it shall be effectively earthed. A chain or hook does not provide effective earth connection.

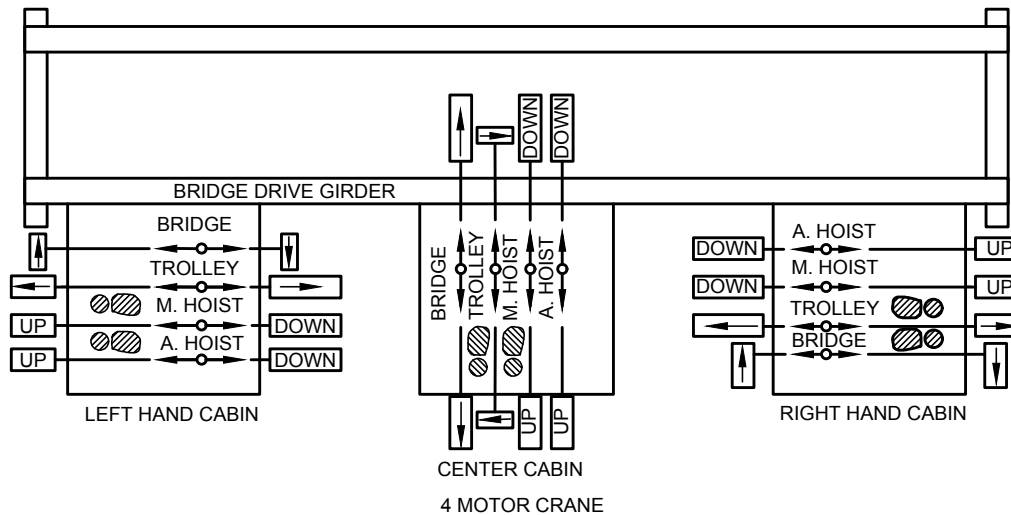


FIG. 11 RECOMMENDED ARRANGEMENT OF CONTROLLERS

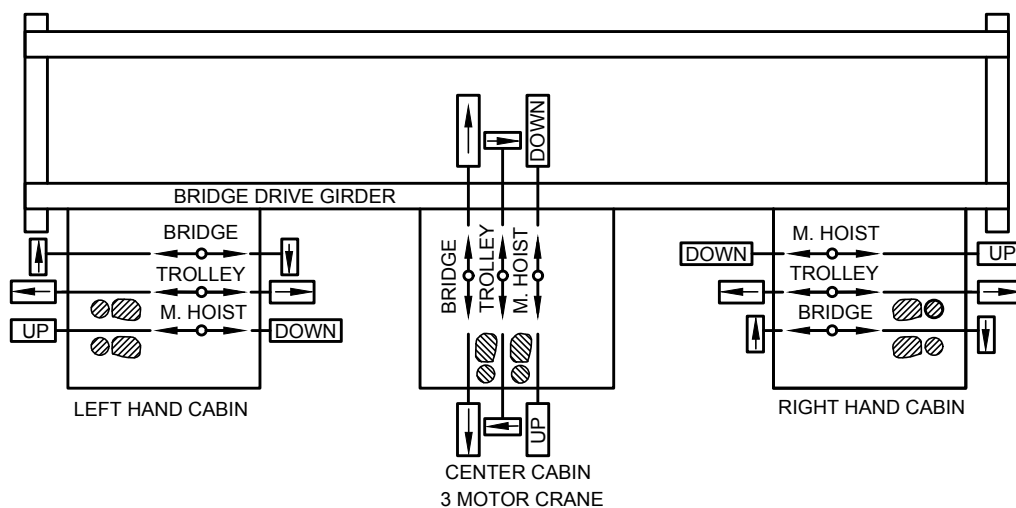


FIG. 12 RECOMMENDED ARRANGEMENT OF CONTROLLERS

53.5 Remote Control

53.5.1 Main features of radio remote control system consist of:

- a portable transmitter;
- an antenna and receiver on the bridge; and
- an intermediate relay panel on the bridge to amplify the signals for the crane contactors.

53.5.2 Radio controls should be designed so that if the control signal for any crane motion becomes ineffective, that crane motion will stop, and conversely signals received any source other than the transmitter

will not result in operation of any motion of the crane. The crane must not take off on its own or respond to or generate false commands. In case electricity failure occurs, the crane must stop.

A key switch or equivalent security device on the transmitter that can be used to prevent unauthorized use of the transmitter.

The sending of a continuous or continuously repeating secure signal when transmitter is in use, which the crane receiver can identify. A secure signal includes at least three characteristics separately recognizable by the receiver.

An emergency stop device shall be used for emergency stop.

A carrying harness, belt, shoulder strap or lanyard on the transmitter.

53.5.3 The arrangement of the operating levers on the radio transmitter should conform to figures given below. The manufacturers should supply motion switches with different shaped knobs so that the motion can be selected by feel and the operator's vision remain on the load. Modular construction shall be preferable for easy replacement.

53.5.4 Typical frequencies used for radio controls are:

- in between 450 - 470 MH for which license is required; and
- any license free frequency band.

The recommended crane controls for operating are of maximum 100 metre range.

Radio crane control transmitter lever arrangement of four motions, namely, are given below:

Four Motion:

Bridge	Trolley	Main Hoist	Aux Hoist
X ↑ ↓ W	Y ↑ ↓ Z	Down ↑ ↓ Up	Down ↑ ↓ Up

Radio crane control transmitter lever arrangements of three motions, namely, are given below:

Three Motion:

Bridge	Trolley	Hoist
X ↑ ↓ W	Y ↑ ↓ Z	Down ↑ ↓ Up

NOTES:

1 Markings on the crane visible from the floor, shall indicate the direction of bridge and trolley travel corresponding to the W, X, Y and Z designations on transmitter.

2 The maximum working range of radio control shall be limited to 40 – 50 m from the transmitter. This limitation reduces the likelihood of an accident caused by the crane operating beyond the operator's visibility.

3 It is recommended that a device is fitted to the crane to give warning that the crane is under non-conductive control.

4 Incorporate a limited range feature, present by means not available to the operator so that the crane will stop when the extent of that range is reached.

5 If more than one crane are provided with this type of controls, only the intended crane and its motion is operated at one time. The transmitter shall be constructed so that it is capable of withstanding rough handling.

53.5.5 Remote control may be by means of radio or infrared transmission or an off-crane control station connected to the crane through wiring. The control station may consist of pushbuttons, master switches, computer keyboards or combination thereof. For definition of remote control, see the applicable ASME standards. The selection and application of the remote control system shall be done to assure compatibility between the remote control and the crane control system and eliminate interference. When more than one control station is provided, electrical interlocks shall be included in the system to permit operation from only one station at a time. Electrical interlock is defined as effective isolation of the control circuits with the use of rotary switch contacts, relay contacts or with the use of a programmable logic controller and its input/output modules. Due consideration should be given to elimination of interference between electronic signals and power circuits. This includes physical and electrical separation, shielding, etc. Due consideration should also be given to the following:

- operating range of the remote control equipment;
- operating speeds of the crane;
- application of end travel limit switches; and
- wiring of magnet and vacuum circuits to the line side of the disconnecting means and use of latching controls.

54 RESISTORS

54.1 General

Resistors shall be adequately protected to prevent accidental contact with live parts. The elements shall be protected against corrosion.

54.2 Rating

Resistors shall be rated such that the temperature does not exceed the limits specified in the relevant Indian Standard specification, during the operation of the crane under service condition. The resistance and current capacity of the resistors shall be computed according to the actual torque requirements of the motion served and not on the motor size which may be set by thermal requirements. The effect of using plugging as a service brake shall be taken into account in determining the size of resistors. Resistors shall be rated according to the service conditions and the mechanical class of the crane and shall preferably be intermittent and short

time rated. The rating of the resistors shall not be less than that given in the Table 17.

NOTE — For definitions of different intermittent rating, see Annex G.

Table 17 Rating of Resistors

(Clause 54.2)

Sl No.	Mechanism Class	Short Rating for Time Rated Resistors, <i>Min</i>
(1)	(2)	(3)
i)	M1, M2	2
ii)	M3, M4, M5	5
iii)	M6, M7	10
iv)	M7, M8	To suit the service condition

54.3 Fittings

Resistors shall be enclosed in the well ventilated housings and, wherever necessary be fitted with suitable covers. They shall be mounted outside the main contactor compartment. Resistors shall be mounted on steel frames to withstand forces imposed by the crane under service conditions. They will be arranged in such a way that boxes can be easily replaced. The connections to the resistor terminals should be accessible and adjustable. Resistor assemblies shall not impede the maintenance of the long travel drives or access to any part on the crane. Resistor assemblies for each motion shall be stacked separately for the facility of inspection maintenance and safety.

54.4 Degree of Protection

Minimum degree of protection for the resistors shall be IP 22 or as specified by the purchaser.

55 CRANE CONTROLS

Various types of crane speed controls are as follows:

- d.c. motor with thyristor based controls;
- a.c. slip ring motors with conventional controls using rotor resistances and plugging braking;
- a.c. slip ring motors with thyristor based controls;
- a.c. squirrel cage motors with gear arrangements called 'geared motors' for standard hoists and travel motions; and
- a.c. squirrel cage motors with VFDs.

55.1 Thyristor Control

Main features are as under:

- The thyristor shall be protected by fast acting semiconductor fuses having $12 \times t$ value considerably lower than that of the thyristor. These fuses shall be continuously of any fuse shall result in tripping of the power circuits;

- The thyristor shall be suitable to carry at least 200 percent of the drive motor current rated S3-40 percent. The PIV of the thyristor shall be 2.5 times the system peak voltage appearing across the thyristors. The factor 2.5 has been selected taking into account the line voltage variations;
- Each thyristor shall be protected by RC snubber circuits so as to absorb the surges generated out of external line surges in consultation with the user;
- The drive system shall be protected against overload by means of thermal overload or oil dash pot of magnetic overload type with inverse characteristics having adjustable setting range. It shall also be protected against over current by means of instantaneous acting over current relays having a setting range of 200 to 400 percent of the drive rated current. Solid state overload protection may be used subject to the agreement of the purchaser;
- Switching-off of reversing contactors shall be done at near zero current. This is to be done by ensuring that the stop/tripping command first inhibits the thyristor controller and then switches 'off' the reversing contactors. This requirement will not be applicable, if the reversing is through thyristors;
- In the case of overloading or the single phasing of the synchronizing supply, the circuits shall be tripped immediately;
- Whenever armature reversal (in case of the dc drive) or stator reversal (in case of the a.c drive) is to be done through the reversing contactors, the drive shall be protected against the free fall conditions at the time of switching on and reversals by having the preferred switching state of the reversing contactor. The drive controller shall have suitable provisions for preventing load drifts at the time of start and stop;
- For achieving smooth acceleration of the drive mechanism suitable ramp generator circuit shall be available with the controller;
- Wherever necessary, suitable de-rating would be considered for a.c./d.c. motors in consultation with the thyristor controller manufacturer and the motor manufacturer;
- The control circuits shall be so designed that the brakes are applied at around the zero speed;
- Test points shall be available in the cards. Alternatively for digital device the HMI should have necessary display facility;
- In case of wide deviation of the speed in actual value from the set value, the circuit shall trip the mechanism immediately. During acceleration or deceleration period such tripping shall be prevented by adjustable time setting;

- q) Thyristor control shall be suitable for operation at vibration levels and environments encountered in the crane operation;
- r) If specially required by the purchaser, the drive motor shall be protected against overheating by means of thermistors embedded in the motor winding. Matching thermistor for trip relay shall be provided by in the control panel. The embedded thermistors are best for preventing overloads and subsequent overheating of the motor as these thermistors give the correct thermal image of the motor irrespective of the current carried.; and
- s) Wherever a.c. phase controllers are to be paralleled for load sharing, the converter outputs shall be paralleled only at the load end and not at the converter end.

55.2 Special Protection for Direct Current Drive System

- a) To minimize excessive rate of rise of armature current and radio frequency interference, commutating chokes with sufficient inductance shall be provided on the a.c. side so that PU (inductive drop) across the choke lies between 2 and 4 percent. Where isolating transformer is used, commutating chokes are not necessary;
- b) To prevent excessive wear and tear of the commutator, the ripple content of the d.c. output shall be minimized by providing smoothening chokes of sufficient inductance depending upon motor design;
- c) In case of the quadrant drives, to protect against inverter commutation failure during regenerating mode, branch thyristor fuses shall be used. However, where it is not possible to use branch thyristor fuses, there shall be at least one fast acting semiconductor fuse on the d.c. side of the converter in addition to the semi-conductor fuses on the a.c. side;
- d) While switching on the system, the following sequence shall be adhered to:
 - 1) Synchronizing supply is switched 'ON',
 - 2) Field circuits are established, and
 - 3) a.c./d.c. contactors are switched 'ON'.
- e) The drive shall be protected against field failure with suitable circuits; and
- f) The field current shall be reduced to a safe value during the crane idling time to reduce the heating of the motor. The normal field current shall resume at the start of the drive operation.

55.3 Thyristor Controllers for Slip Ring Motors

The thyristor controller should be a dedicated controller for crane application. It should be with microprocessor based closed loop, thyristor controlled adjustable a.c. voltage control. The current rating of thyristor drive shall

be selected corresponding to F.L. current at electrical kW. Rating of each thyristor (for example, I_{tan}) shall be minimum 0.45 times I_{rms} . The current rating of rotor contactors and resistance grids shall preferably be about 125 percent to 150 percent of rated current (depending upon minimum speed required to achieve) which may be confirmed by thyristor drive manufacturer. The thyristor controller should be rated at maximum of (+) 65°C and should be operational for a supply voltage variation of -15 percent to (+) 10 percent. The commissioning and trouble shooting should preferably be done through the in-built key pad on the drive for ease of operation and maintenance in steel plant cranes. If possible the key pad should be detachable type with provision to store the drive data sets and parameters, allowing user flexibility to upload / download data. However, provision for programming / trouble shooting from LAPTOP / PC should also be available.

55.4 Variable Frequency Drives

When asynchronous motors are fed from VFDs, the speed can be changed by changing the frequency of the supply (to the motor). Up to, the base speed/frequency of the motor (50 Hz), the constant flux is maintained (see Fig. 13) thereby allowing the motor to deliver constant torque through out the range from 0 - 50 Hz. The complete pull out torque of the motor is available at the time of starting. The normal torque speed characteristics of the motor (at 50 Hz) shifts towards the origin with the lowering of frequency. In the field weakening region above the nominal motor speed / frequency, the motor's rated torque decreases proportional to the increase of frequency and the maximum torque (pull out torque) decreases inversely proportional to the square of the speed. The frequency above the rated, sets the limitations to the use of field weakening. The motor is operated ensuring constant power in field weakening zone as well as availability of pull out torque for required operation.

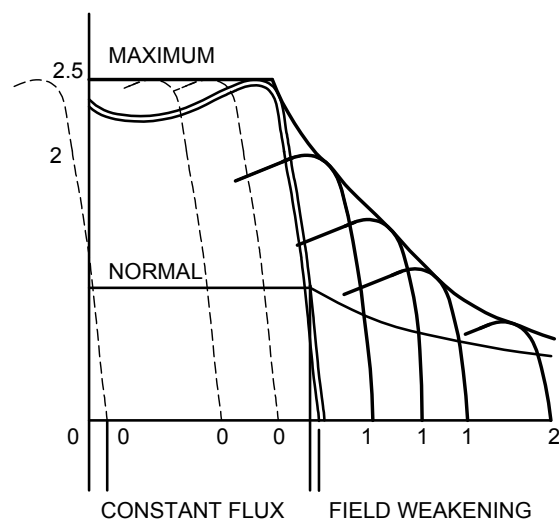


FIG. 13 TORQUE SPEED CURVES CHARACTERISTICS

55.4.1 VFD Selection

- a) The VFDs selected for crane application should be insulated gate bipolar transistor (IGBT) / diode/thyristor based, converter and inverter both.
- b) Inverter selection shall be based on inverter manufacturer's recommendation given due consideration of the following:
 - 1) Application,
 - 2) Power factor and efficiency of the motor at the load point,
 - 3) Power supply,
 - 4) Actual current at mechanical kW (P_{mech}), and
 - 5) Operating ambient temperature.
- c) VFDs should always be selected based on the heavy duty current rating mentioned in the manufacturer's catalogue. In case of dual current rating mentioned in the catalogue, the current rating corresponding to 'constant torque' or 'heavy duty' should be selected for crane applications.
- d) The continuous current rating of the VFD shall be at least equal to the motor current at the highest speed maintaining torque. The current required by the motor at any foreseen loading, including dynamic situations shall not exceed the short time rating of the VFDs.
- e) The squirrel cage motors shall be of inverter duty. These motors may not be suitable for DOL starting, hence, same shall not be used for direct online starting with bypassing VFDs.
- f) VFDs shall be provided with dynamic braking facility with braking resistor or fully regenerative capability (active front end type).
- g) VFDs shall be provided with proper branch circuit protection on the line side.
- h) Distorted waveforms on the line and/or short circuit current may require the use of line reactors, isolation transformers or filters.
- j) Line contactor shall be used with VFDs for hoisting applications to disconnect power from drive in case of over speed or fault.
- k) A minimum of two collectors for each runway conductor shall be furnished with inverter use.
- m) The cranes using VFD controls shall adhere to the crane safety standards mentioned by IS 16504 (Part 32).
- n) Starting current of motor shall be limited within 150 percent of the maximum operating motor full load current or more if required.
- p) VVVF drive should be selected suitably so that the drive can perform under overload of 150 percent of maximum operating full load current of motor (that is, FLC corresponding to mechanical kW) for 60 s in every 300 s.

- q) For cranes under operation in steel melting shop having high ambient temperature of more than 50°C as well as dusty condition for example, charging crane, ladle crane, hot slab handling cranes, VFDs should be provided with A/C unit with filter arrangement and be suitably protected with proper enclosure protection to tune of IP-54 / 55 degree or should be housed inside crane girder or electrical room on crane platform.
- r) Rating of VVVF drives, however be selected with sufficient margin, to take care of steady state and accelerating torque demand at maximum operating point i.e. full load current at full speed of respective motion.
- s) VFD rating for M7 and M8 duty class (charging crane, ladle crane and hot slab handling cranes) application is recommended to be 150 percent of motor full load current at mechanical kW.

55.4.2 Dynamic Braking Selection for VFDs

For the hoisting motion, the braking occurs when the load is lowered. The braking resistor of a hoisting drive shall be selected considering the possible lowering height of the load being lowered at the maximum speed. The calculated regenerative energy and the lowering time can be used for designing the braking resistor. The hoisting drive should preferably have the flexibility of connecting external braking units (IGBT based) along with the resistors. The hoisting drive along with the register may also have inbuilt IGBT as the chopper. For horizontal motions, the braking resistor shall be capable of absorbing the regenerative energy during deceleration of the motion also taking into account the possibility of a swinging load and the wind push (the load and load attachment included). The braking resistor shall be thermally capable to absorb the generative energy during successive drive cycles of the application.

56 BRAKING**56.1 Electro-Mechanical Braking****56.1.1 General**

Brakes shall be provided for each drive. At least one brake shall be mounted on the input pinion shaft of the gear train. Cranes, which require particular safety, for example, in steel works or with dangerous or melted loads, should be provided with a second brake. The operation of the second brake shall be arranged according to the design of the drive. It is recommended that under normal operating conditions, the second brake is always being applied on stopping, after the motion has been brought to a halt by the main brake. In some applications for example, if waiting for the releasing of the second brake would cause unacceptable time delay at each starting, it may be necessary to apply the second brake only when the crane switch (main contactor) is

de-energized. In the event of an emergency stop, the second brake should be applied immediately.

56.1.2 Hoist Motion

Electro-mechanical brake/brakes used for hoist motion shall apply automatically when the power supply fails or when the circuit brake is opened or when the controller handle is brought to the 'off' position. For hoists not handling molten metal and having single brake only the minimum braking torque shall be 150 percent of computed full load "computed full load torque, which is to be derived from below formula:

$$\text{Braking torque (in kg.m)} = 975 \times P_{\text{mech}} / N$$

Where,

P_{mech} = Mechanical KW (as per 50.2); and

N = Motor RPM.

When two brakes are fitted each shall have braking torque not less than 125 percent of the computed full load torque. Hoists handling molten metal shall have two brakes on each drive and each brake shall have minimum braking torque of 125 percent of computed full load torque. For a.c. cranes when two brakes per motor are used, the second brake may be fitted with a time lag in which case the braking torque shall not be less than 125 percent of the computed full load torque for each brake.

56.1.3 Braking Path

The braking path of the hoist motion should be within the distance as per Table 18 with all the brakes applied simultaneously, except the effect of brakes with time lag:

Table 18 Braking Path
(Clause 56.1.3)

Sl No.	Speed of Hoist (v in m/min)	Max. Braking Path (in m)
(1)	(2)	(3)
i)	$v < 6$	$v/100$
ii)	$6 < v < 12$	$v/120$
iii)	$v > 12$	$v/150$

56.1.4 Emergency Braking for Ladle Cranes, if Asked by Purchaser

This is for the failures of any mechanism in between motor shaft to rope drum shaft, including internals of gear boxes. If emergency disc brake of hydraulic caliper type is provided on hoist rope drum, then pressure accumulator should be built-in on hydraulic power pack to avoid any mal-operation in the event of failure of the motor of the power pack. This brake

should be selected based on minimum 150 percent of hoisting torque and be actuated through over speed sensor mounted near or on rope drum extended shaft. Brake selection should be cross checked with respect to specified braking path or within 65 mm, whichever is less so that the load stops within safe distance to prevent any fatal accident or damage to any equipment. Hydraulic disc brake is applied by release of hydraulic pressure during emergency. With accumulator assisted hydraulic system application time of brake shall be longer which may not be acceptable in case of emergency as such requirement pressure accumulator may be reviewed. Speed encoder/transducer must be provided on the rope drum shaft, to compare the motor shaft encoder for generating signal for actuation of the emergency braking:

- Any other disc brake arrangement; and
- These are to be suitably designed with the manufacturer.

56.1.5 Long Travel and Cross Travel Motions

Braking torque shall be checked so that it is capable of arresting the motion within a distance, in metre, equal to 10 percent of speed, in m/min, when travelling with rated load at rated speed, provided there is no skidding. Long travel motions of outdoor cranes shall be provided with an additional storm brake. The combined braking torque of the service brake shall not be less than the skidding torque assuming a coefficient of friction (μ) = 0.2. For long travel drives anchoring device shall also be provided for outdoor cranes in addition to storm brakes. All other motions, such as, slewing shall be provided with effective braking system which can be applied in an emergency or would be applied automatically in the event of failure of power supply.

Each drive shall be fitted with an electro-mechanical brake having braking torque not less than 100 percent of computed full load torque, which is to be derived from below formula:

$$\text{Braking torque (in kg.m)} = 975 \times P_{\text{mech}} / N$$

Where,

P_{mech} = Mechanical KW (as per 50.3.2); and

N = Motor RPM.

56.2 Electrical Braking

In addition to specific requirements of this code in regard to the provision of electro-mechanical brakes, and irrespective of the supply current system, electrical braking is permissible and recommended on all motions of electrically operated cranes. When electrical braking is used, provision shall be made to limit the current on reversal to a safe value. Effective means shall be provided for stopping the motion in the event of power failure and in the case of emergency.

56.3 Brake Magnet Coils

All magnet coils shall be fed from d.c. or a.c. supplies, and the rating of brake magnet coils shall be as given in Table 19. The brake shall operate at the voltage and current values specified in Table 20 given below. Shunt magnets shall meet the requirements when the coils are at a temperature which corresponds to energization under rated conditions.

The temperature rise of coils shall not exceed that permitted by relevant Indian Standard for the class of insulation employed.

NOTE:

Brake Surfaces — The rubbing surfaces of brakes shall be smooth and free from defects. The temperature attained by the rubbing surfaces under service conditions shall be such that their operation is not impaired.

Table 19 Brake Magnet Coil Ratings
(Clause 56.3)

SI No.	Winding	Brake Duty	Rating
(1)	(2)	(3)	(4)
i)	Shunt	Emergency	Conditions (with economy resistance inserted where necessary)
ii)	Shunt	Intermittent operation, any motion	1 h
iii)	Series	Hoist	30 min

Table 20 Brake Magnet Operating Voltages and Currents
(Clause 56.3)

SI No.	Winding	d.c. Magnets	a.c. Magnets
(1)	(2)	(3)	(4)
i)	Shunt	Lift at 80 percent rated voltage Hold at 50 percent rated voltage	Lift at 80 percent rated voltage Hold at 50 percent rated voltage
ii)	For series resistor	Lift at 40 percent rated current	—
iii)	Series or potentiometer control	Hold at 15 percent rated current	—

57 FLOOR CONTROL — WITHIN CONTROL FEATURES

57.1 Control Circuits

If the mains supply is a.c. and the control circuits are supplied at reduced voltage, the supply to these circuits shall be from the secondary winding of an isolating

transformer or an isolating transformer and rectifier. The transformer frame and one pole of this supply shall be earthed and the contactor and relay coils shall be connected to this pole. An earthed screen shall be provided between the primary and secondary winding. The primary winding and unearthed pole of secondary winding of the transformer shall be protected by fuse in line connection. Effective means shall be provided to prevent mal-operation owing to short circuits or earth faults.

57.2 Rectifiers

On a.c. cranes, if d.c. supply is required, rectifiers shall be provided for supplying the control circuit, brakes and magnets. These rectifier units shall be of adequate capacity to supply the full d.c. loads required continuously. They shall be of suitable construction and mounting to withstand heat, dust, shock and vibration. Silicon type rectifier units shall be preferred. Adequate fuse protection shall be provided for the rectifiers. Rectifiers/thyristors used for magnets shall be protected against switch surges.

57.3 Control for d.c. Supply

When a d.c. supply circuit is used, motor acts as a generator in the lowering direction, the control shall be such that:

- motor shall not exceed a pre-determined maximum revolutions per minute;
- progressive degrees of braking is provided;
- adequate light hook lowering speed is provided;
- brake is prevented from being released by back emf of the motor when power supply is interrupted; and
- electro-mechanical brake is automatically applied when circuit breaker or contactor is opened.

57.4 Braking Controls

When an electro-mechanical brake is used as an emergency or parking brake or when such an emergency or parking brake is used with hand or foot operated travel service brakes, the brake actuating device shall remain in the circuit when the main circuit breaker is closed. The brake shall apply automatically when the power supply fails or when the circuit breaker is opened or on operating an emergency stop push button or switch, but not when the controller handle is brought to the 'off' position. The brake shall lift off when voltage at the coils is a minimum of 85 percent of rated voltage. Provision shall be made for emergency application of this brake by means of the emergency stop push button or switch. In the arrangement of connections to the hoisting motion brake coils, means shall be provided to ensure that when associated drive motors are de-energized, the stored electrical energy in these motors will not delay the application of the brake.

57.5 Acceleration Control

Automatic control of acceleration shall be provided for all crane motions, unless for any motion another control system is specified. The hoist motion circuits shall enable any load to be lowered with safety and the hoist motors shall remain under effective control with the controller in all positions. While calculating the number of rotor contactors, peak accelerating/decelerating torques and pull out torque of the motor should be taken into account.

For creep lowering speed on hoisting motion, relatively flat speed control shall be provided. Peak accelerating/decelerating torque shall be considered as minimum 180 percent of full load torque for cranes under M6 to M8 mechanism class.

58 AUXILIARY REQUIREMENTS

58.1 Lighting on the Crane

Necessary lighting arrangement for approaches and for carrying out maintenance work without danger shall be provided by the crane manufacturer in consultation with the purchaser. The nominal voltage of lighting circuits shall not exceed 250 V. 220 V a.c. can be used for hand lamp if circuit is protected with earth fault. If hand lamp is provided it shall not be connected to a circuit exceeding 250V d.c. or 25V a.c. supply. In the case of an a.c. circuit hand lamp shall be fed through a double wound isolating transformer with some part of the secondary winding earthed. The primary winding of the transformer shall be controlled by a double pole switch. Fuses or MCB shall be provided in each pole of the primary circuit and one pole of each of the secondary circuits.

58.2 Cabin Lighting

The cabin and the panel room shall be provided with adequate lighting.

58.3 Under the Bridge Lighting

Under bridge lighting, if required by the purchaser shall be mounted on shock absorbers and so installed that they can be serviced easily.

58.4 Other Provisions in the Cab

As required by the purchaser fans, air conditioners or cabin heating arrangements shall be provided by the crane manufacturer.

58.5 Crane Warning Signals

If required by the purchaser, the crane shall be equipped with warning lights on both sides of the crane and/or sound signals to indicate approach of the crane or hook. Each warning light fitting shall contain two LED connected in parallel. Each fitting shall be provided with an anti-vibration mounting and shall be accessible.

They shall not interfere with the driver's vision and shall be readily visible to the concern persons.

59 HEATING AND AIR-CONDITIONING

59.1 Machinery House

Natural or forced ventilation should be provided to disperse thermal power generated by the machinery and its equipment. Where electronic equipment is used and working conditions do not guarantee an ambient temperature for proper functioning of the electronic equipment, an air conditioning unit should be provided.

59.2 Operator Cabin

If necessary, heating appliances should be provided in the cabin. This apparatus of black heat/non radiant type shall be securely fixed. It must be provided with a thermostat and must have such a power to assure a minimum temperature of $25 \pm 2^\circ\text{C}$, taking into account the environment in which the equipment is installed. This apparatus must be fed independently of the principal circuits of the hoisting appliance. If required by the environment an air conditioning unit should be installed in the cabin to maintain a maximum acceptable temperature. This apparatus must be fed by a circuit independent of the principal circuits of the hoisting appliance.

60 AUXILIARY CIRCUIT

If there is no possibility of supply in the proximity, auxiliary circuits should be provided for maintenance purposes, as follows:

- a) A circuit for portable lighting, if the ambient lighting is not sufficient to carry out maintenance;
- b) A circuit for portable tools according to agreement between customer and supplier; and
- c) These circuits should be protected by a differential circuit breaker of high sensitivity and they shall be independent of the principal circuits of the hoisting appliance.

61 LIFTING MAGNETS AND LOAD HOLDING DEVICES

61.1 General

The requirements given in this clause apply to all load holding devices, such as, lifting magnets and vacuum lifters. Load holding devices are normally designed to a cyclic duration factor of 50 percent. Other cyclic duration factors should be as agreed to between the manufacturer and the user.

The tear-off force should be at least twice the lifting capacity. If there is a stand-by power supply from batteries, the holding time should be at least 20 min. In this case, an automatic charging unit and a charge

level indicator should be provided. Use of the stand-by supply should be indicated visually and audibly for general warning. If the battery voltage level is not adequate, a device preventing the installation from being used should come into effect. If required by the purchaser, the crane shall be fitted or provision shall be made to permit in the future fitting of lifting magnets, magnet control and protective gear.

61.2 Magnet

The type and size of magnet shall be decided based on the details given by the purchaser. The type and size of magnets shall preferably be in accordance with details specified in Annex D.

Each magnet will be water tight and shall be provided with a water tight terminal box having the under mentioned features, however rectangular magnets are normally of fabricated construction type also can be used as follows:

- a) Integral construction with magnet casing;
- b) A gland through which the magnet load is brought to the magnet terminals;
- c) A cover which shall be easily removable without interfering with the magnet lead inlet;
- d) Adequate thickness of box and cover; and
- e) Non-linear type discharge resistor of adequate rating and the rectangular magnets are fabricated constructions and nice fabricated type of magnets.

61.3 Magnet Lead and Cable

The magnet lead and cable shall be flexible three core cables. If specified by the purchaser, the magnet lead shall be protected by rubber hose complying with the relevant Indian Standard. The magnet lead shall be so arranged that it does not become unduly slack or taut during normal operation of the crane. It should be so located that magnet cable does not foul with the rope. The use of sheaves and rollers for the cable should be avoided as far as possible. The magnet cable shall be rigidly attached to the bottom block by a suitable cable clamp at a point above magnet coupling.

61.4 Magnet Couplings

The type of magnet coupling shall be as agreed to between the purchaser and the supplier. The coupling shall comply with the following requirements:

- a) Couplings shall be of rugged construction;
- b) At the moment of breaking, the contacts shall be enclosed by insulating material and earth connection shall break last;
- c) Provision shall be made to fasten the coupling in the closed position; and
- d) Socket shall be connected to the supply and plug to the magnet or magnet lead.

61.5 Cable Drum

The magnet cable drum shall be as follows:

- a) Arranged so that magnet cable does not foul with the hoisting ropes;
- b) Such that the cable will become neither unduly taut, nor slack enough to touch the hoist ropes or get entangled; and
- c) Capable of accommodating and paying out the length of cable necessary for the magnet to reach its lowest position.

Cable drum when attached to the hoist drive, a disengagement device shall be provided. Where power is fed to the magnet by a brush and slip ring arrangement on the magnet cable drum, two brushes per slip-ring shall be provided and the rings shall have adequate clearance. The slip ring insulation shall be of non-tracking material and the assembly shall be enclosed by an easily removable cover, oil-proof for indoor cranes and weather proof for outdoor cranes. A spare slip ring complete with brush gear arrangement shall be provided, if required by the purchaser.

61.6 Magnet Control and Protective Equipment

The magnet shall be controlled either by direct-online control or potentiometer control as required by the purchaser. In both methods of control the magnet shall be demagnetized by current reversal. In direct-on-line control, the magnet shall be energized by switching it across full mains voltage and discharge resistance shall be connected on switching 'OFF'. The control shall be affected by means of a master controller and magnetic contactor panel.

61.7 Battery Back up System

If required by the purchaser, necessary and adequate battery back up system shall be provided by the supplier. The rechargeable battery shall keep the magnet energized till the time the lifted load is brought to a safe location, in the case of power failure. If there is a stand-by power supply from batteries, the holding time should be at least 20 min. In this case, an automatic charging unit and a charge level indicator should be provided. Use of the stand-by supply should be indicated visually and audibly for general warning. If the battery voltage level is not adequate, a device preventing the installation from being used should come into effect.

62 ELECTRICAL EQUIPMENTS LOCATED ON THE CRANE BRIDGE

62.1 General

Electrical equipments mounted on bridge platform shall be enclosed in suitable enclosure with provision for easy access to the parts inside. The units shall not

impede the maintenance of the long travel drives. The control panels or units shall be so spaced that efficient maintenance is possible. They shall withstand the mechanical forces imposed by the crane under service conditions. For cranes working in open yard, electrical equipments shall be of weather-proof construction for the duty. Control panels and other electrical equipment shall be so located that there is no chance for oil or grease falling on them. The thorough fare between any portion of the crane and the exit platform shall not be impeded by any control unit. However, also refer the below given Table 21 for information may suitably used for the enclosures, where discussed.

62.2 Identification of Circuits

All switches, fuses, panels, controllers, resistors connectors and other electrical elements of controller panels shall be adequately labelled or marked by furnishing functional nomenclature to facilitate identification of the circuit. All main and control wires and conductors shall be ferruled and numbered at both ends as per drawing for quick identification. All equipment terminals shall be numbered and tagged.

Table 21 Information for Enclosures

(Clause 62.1)

Sl No.	Equipment	In-Door	Out-Door
(1)	(2)	(3)	(4)
i)	Control panel	IP 54	IP 55 (with double door)
ii)	Limit switches	IP 54	IP 55
iii)	Resistances	IP 22	IP 33
iv)	Motor	IP 54	IP 55
		(without cover)	(with cover)

63 DRAWINGS

A wiring diagram of the crane shall be supplied by the manufacturer. The diagram shall give the rating of each motors, the cable sizes and such other information which will facilitate inspection and maintenance of the crane. All electrical elements shall be designated by functional nomenclature and numbered for identification. All main and control wires and terminals shall be numbered to facilitate wiring and identification while maintaining. A schematic diagram shall also be supplied for contactor controlled cranes along with the list of parts used. In addition to the drawings the following drawings and documents may also be provided as given below:

- External termination drawings and cable schedule; and
- GA drawings of control panels.

SECTION 4 INSPECTION AND TESTING

64 INSPECTION PROCEDURE

64.1 General

If required by purchaser and specified in the contract, the purchaser or his authorized representative shall have access to the manufacturer's works at all reasonable times for the purpose of witnessing the manufacturer, inspection and testing of all products concerned and/or the complete crane.

Any work found defective or which is not in accordance with the drawings or of the terms of this code and/or contract may be rejected by the inspector (*see* Fig. 14, 15 and 16).

64.2 Test at Manufacturer's Works

All electrical and mechanical equipment shall be tested in accordance with the appropriate Indian Standard at either the crane maker's or equipment manufacturer's works and test certificates provided, if required by the purchaser.

If required by the purchaser and specified in the contract, the crane shall be tested at manufacturer's works under full load and 25 percent overload of hoisting and cross traverse motions. Travelling gear may be run light to check shaft and gear alignments. The load test shall be carried out at the manufacturer's premises and/or purchaser's premises as mutually agreed between the manufacturer and the purchaser.

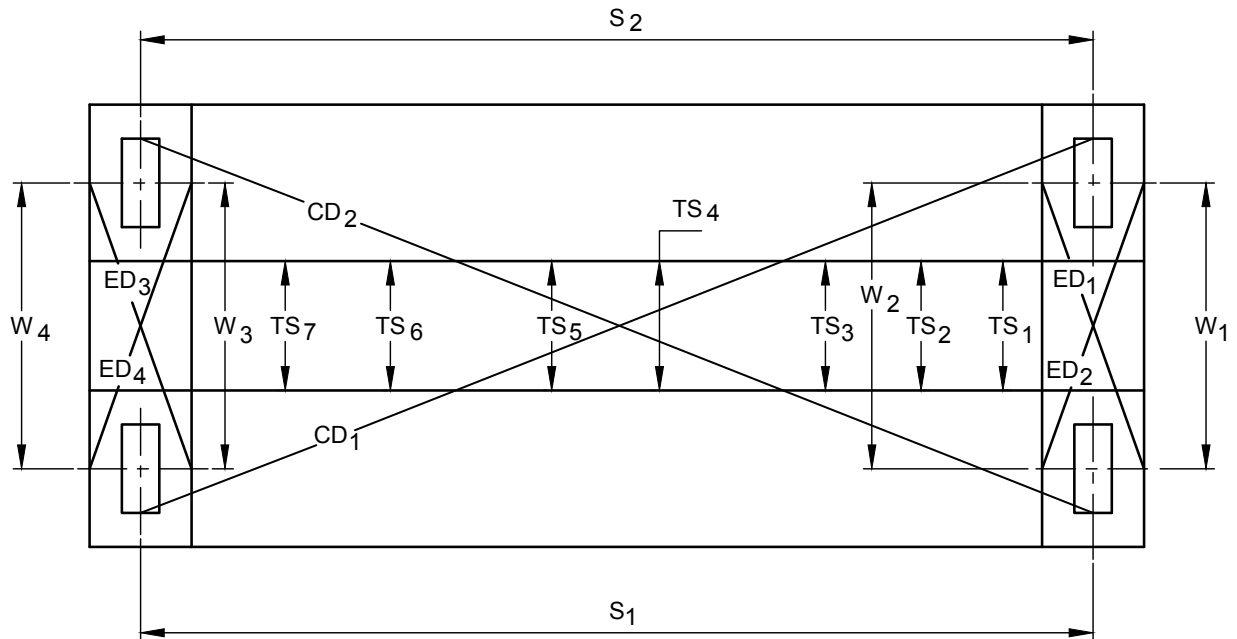
Any test required by the purchaser beyond those called for in the appropriate Indian Standard shall be subject to mutual agreement and shall be carried out at the purchaser's expense.

64.3 Trolley Movement Over Bridge Girder

Whether all the 4 wheels are in contact with the rails at all places.....

64.3.1 Checking of Axial and Angular Misalignment

Quality of Alignment of Geared Couplings	Axial Misalignment mm	Angular Misalignment degree
a) Main hoist		
b) Auxiliary hoist		
c) Cross traverse		
d) Long travel		

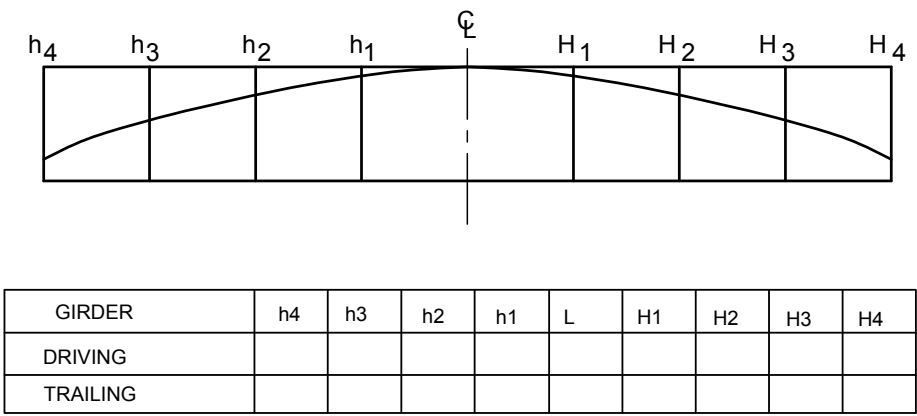


DATA	W1	W2	W3	W4	ED1	ED2	ED3	ED4	S1	S2	CD1	CD2
SPECIFICATION												
ACTUAL												
TOLERANCE												

DATA	TS1	TS2	TS3	TS4	TS5	TS6	TS7	REMARKS
SPECIFICATION								
ACTUAL								
TOLERANCE								

CRANE LOCATION :
 CAPACITY AND TYPE :
 CRANE MANUFACTURER :
 ORDER NUMBER :
 DATE OF INSPECTION :
 PLACE OF INSPECTION :

FIG. 14 CRANE DIMENSIONS

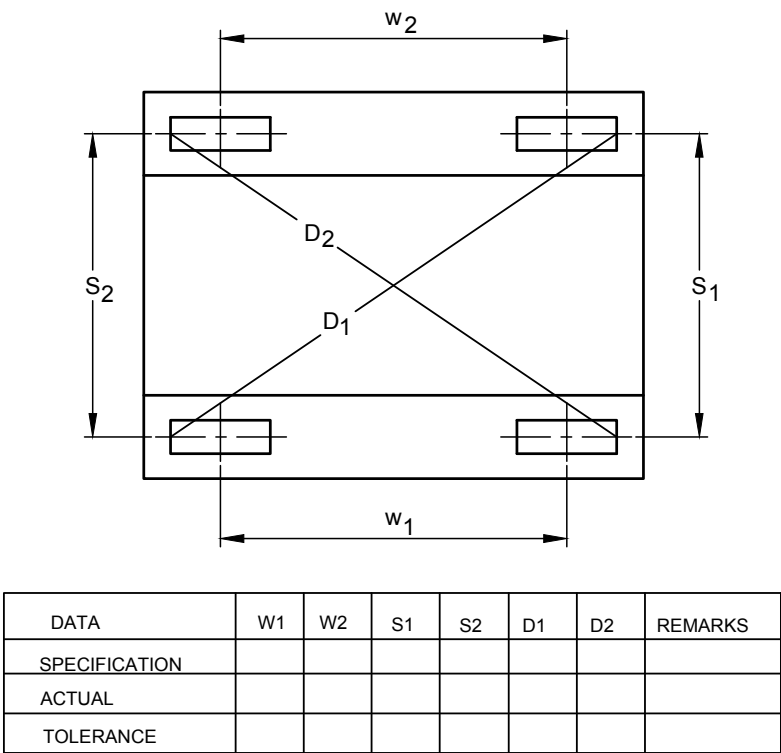


- a) DEFLECTION DUE TO DEAD LOAD OF BRIDGE GIRDER :
- b) DEFLECTION DUE TO TROLLEY :
- c) DEFLECTION DUE TO RATED LOAD :
- d) ACTUAL CAMBER :
- e) ACTUAL DEFLECTION :

REMARKS:

NOTE:- USE WATER LEVEL TO TAKE READING

FIG. 15 SPACING DIMENSIONS



REMARKS :

FIG. 16 TROLLEY DIMENSIONS

64.3.2 Condition of Cable Trolleys

- a) Are they provided with ball bearings:
- b) Are they fitted with single flanged wheels:
- c) How many wheels per trolley:
- d) Number of trolleys:

64.3.3 Performance of Mechanisms (Each Mechanism should be Run for 30 min Continuously for this Test)

- a) *Long Travel* (No load running on sleepers or on test bench)
 - 1) Noise level from gear box.....
 - 2) Oil leakage through input and output shaft.....
 - 3) Linear speed of wheel treated at full speed.
 - 4) Hardness of gears/ pinion.....
 - 5) Material of gears/ pinion.....
- b) *Main Hoist*
 - 1) Noise level from gear box
 - 2) Oil leakage through shafts
 - 3) Surface speed of wire rope drum
 - 4) Hardness of gears/pinion
 - 5) Material of gears/pinion
- c) *Auxiliary Hoist*
 - 1) Noise level from gear box
 - 2) Oil leakage through shafts
 - 3) Surface speed of wire rope drum
 - 4) Hardness of gears/pinion
 - 5) Material of gears/pinion
- d) *Cross Traverse*
 - 1) Noise level from gear box
 - 2) Oil leakage
 - 3) Linear speed
 - 4) Hardness of gears/pinion
 - 5) Material of gears/pinion

64.3.4 Hardness

- a) Long travel wheels
- b) Cross traverse wheels
- c) Permissible values

64.3.5 Material of Wheel for LT, CT**64.3.6 Hardened** (Process of hardening)**64.3.7 Checking of Protective Coating**

<i>Painting</i>	<i>Actual</i>	<i>As per Specification</i>
a) Prime coat		
b) Finishing first coat		
c) Second coat		

64.3.8 Checking of Nut and Bolt

<i>Bolt Holes Alignment</i>	<i>Fit bolts</i>
(Tolerance level of bolts and holes)	(Reamed holes)
a) Bridge girder splice	
b) Gantry leg splice	
c) End carriage splice	
d) End connection (end carriage and girder)	

64.3.9 Idle Running and Speed of the Motor

a) Main hoist .....	.....
b) Auxiliary hoist .....	.....
c) Cross traverse .....	.....
d) Long travel .....	.....

64.3.10 Electrical

Motors (idle running and measuring the no load and full load current):

a) Main hoist .....	.....
b) Auxiliary hoist .....	.....
c) Cross traverse .....	.....
d) Long travel .....	.....

(variable speeds of different motion under no load and load condition)

	<i>Main Hoist</i>	<i>Auxiliary Hoist</i>	<i>Cross Traverse</i>	<i>Long Travel</i>
I notch				
II notch				
III notch				
IV notch				
V notch				
Rated speed				
as per specification				

64.3.11 Checking of Controls

<i>Control Panel</i>	<i>As per Drawing</i>	<i>Actual (IP 54 or IP55)</i>
a) Size		
b) Power contractor size and rating		

c) Rotor contractor size and rating	.....	.....
d) Terminal blocks size	.....	.....
e) Types of wiring	.....	.....
f) Cable (aluminium/copper)	.....	.....
g) Spacing of the contractors and timers	.....	.....
h) Multi hinged doors	.....	.....
j) Type of beeding provided	.....	.....

64.3.12 Wiring

	<i>Crane</i>	<i>Trolley</i>	<i>Cabin</i>
a) Any defect noticed ?			
b) What type of wiring ?			
c) Rectification needed ?			
d) Whether cabin wiring completed ?			
e) Are the different motions as per wiring diagram ?			

64.3.13 Checking of Functions

- Is plugging and reversing functioning?.....
- Is creeping functioning?
- Is counter torque lowering working satisfactorily?
- Is zero speed monitor functioning ?

64.3.14 Resistors

	<i>Main Hoist</i>	<i>Auxiliary Hoist</i>	<i>Cross Traverse</i>	<i>Long Travel</i>
a) Rating and value of resistance in each step				
b) Type of resistor used				
c) Is resistor as per specification?				
d) Lugs to be provided in the terminals				
e) Heating condition during no load and full load testing				

64.3.15 Check the Functioning and Observe

	<i>Main Hoist</i>	<i>Auxiliary Hoist</i>	<i>Cross Traverse</i>	<i>Long Travel</i>
a) Contractors				
b) Timers				
c) Limit switches				
d) Overload protection				
e) Controllers				

64.3.16 Check the Functioning of Accessories

- Ceiling fan
- Warning bell
- Under bridge lighting
- Operator's seat

64.3.17 Insulation Tests

After erection but before the crane is connected to the supply, the insulation of the electrical equipment shall be tested by a suitable instrument and any defects revealed shall be rectified. The voltage required for the insulation resistance test shall be d.c. voltage not less than twice the rated voltage of the system concerned and all phase shall be checked for each crane motion or system. Any reading less than 0.5 MΩ obtained with an insulation resistance tester shall be verified. The wiring under test shall be subdivided until a reading higher than 0.5 MΩ is obtained. Failure to obtain higher reading shows an unsatisfactory state of the insulation and hence shall be rectified.

NOTE — A reading below 0.5 MΩ obtained with such a tester may indicate that unduly low proportion of the prescribed test voltage is in fact being applied. If an installation has been sub-divided for test purposes each sub-division shall meet the requirements. The insulation resistance of each wiring circuit exclusive of connected apparatus shall be not less than 2 MΩ. If necessary, it shall be permissible to disconnect individual items of equipment making this test.

64.3.18 Test Certificate

If specified by the Government of the State in which the crane is to be installed, the tests shall be carried out in the presence of the competent authority appointed, by the concerned industrial safety department of the government. The crane shall be put in use only after clearance and acceptance certificate is issued by the competent authority. The purchaser shall arrange to ensure presence of the competent authority at the time of testing. The manufacturer shall issue a test certificate clearly indicating the tests carried out and results obtained.

65 GENERAL REMARKS**65.1 Welding Inspection Procedures**

65.1.1 Visual Examination (see Table 22 for verification)

Table 22 Certificate

(Clause 65.1.1)

Sl No.	Condition	Acceptable/ Not Acceptable	Reason for Not Acceptable
(1)	(2)	(3)	(4)
i)	The weld has no cracks		
ii)	Complete fusion exists between adjacent layers of weld metal, and between weld metal and base metal		
iii)	All craters are filled to full cross section of the weld		
iv)	Weld profiles are in accordance with Fig. 17		
v)	Permissible frequency and size of piping porosity in fillet welds shall be limited as follows:		
	a) For primary welds not more than 1 mm pore in each 102 mm length and no larger in diameter than 2.4 mm		
	b) For secondary welds the sum of the diameters of piping porosity shall not exceed 9.5 mm in any linear mm of weld and shall not exceed 19 mm in any 305 mm length of weld		
vi)	The actual size of a portion of continuous fillet weld, 9.5 mm or larger, can be under the normal required fillet weld size by 1.6 mm without correction, provided that the under size portion does not exceed 10 percent of the weld length		
vii)	Primary groove welds must have no piping porosity		

65.1.2 Proforma for Welding Profiles Certificate (see Table 23)

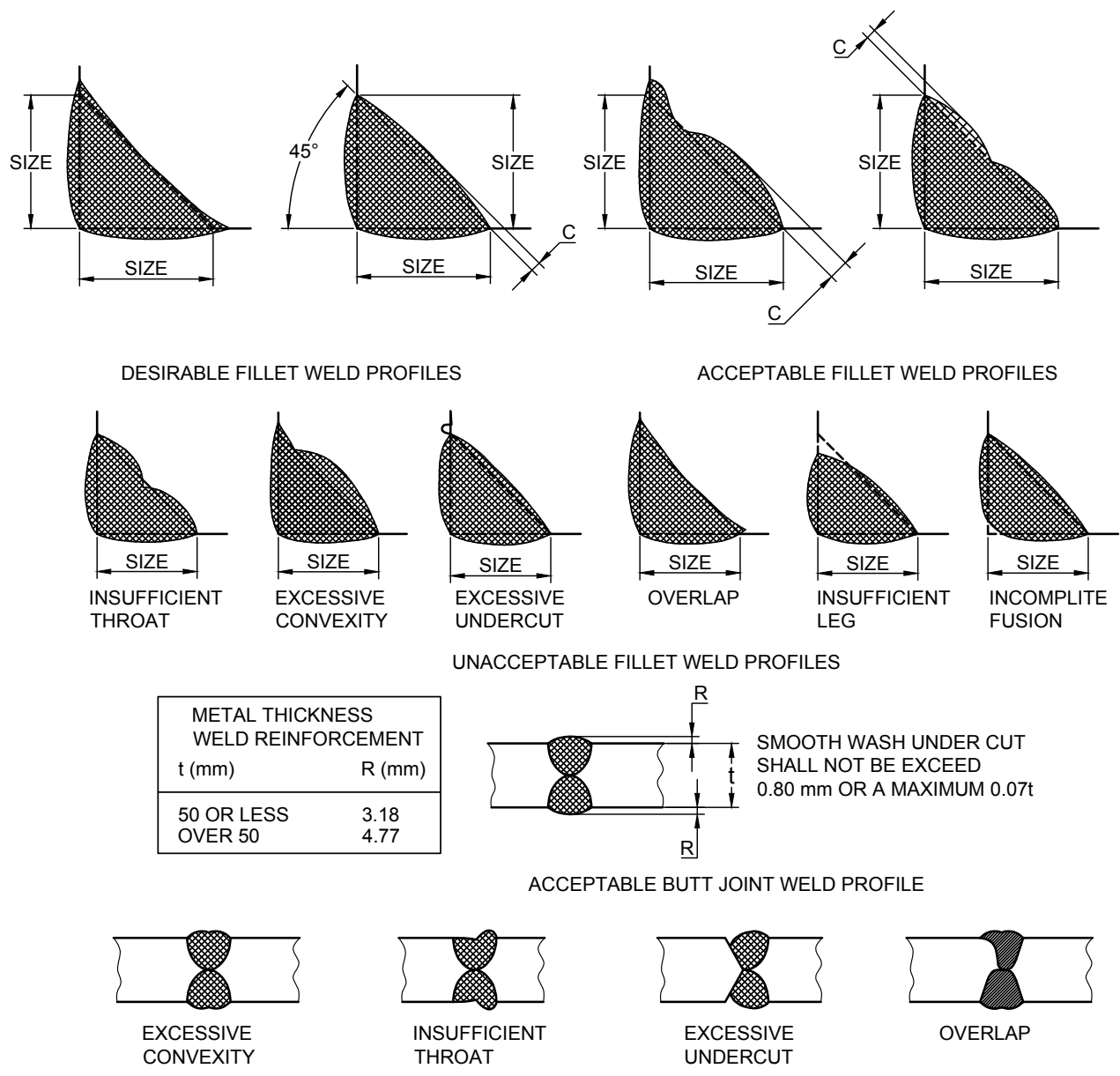
Table 23 Certificate

(Clause 65.1.2)

Sl No.	Condition	Acceptable/ Not Acceptable	Reason for Not Acceptable
(1)	(2)	(3)	(4)
i)	The faces of the fillet welds		
	(a) Convex		
	(b) Flat		
	(c) Slightly concave		
	(concavity must not exceed the sum of $0.1s + 1$ mm where s is the actual size of the fillet in mm)		
ii)	a) Groove welds must be free of the discontinuities.		
	b) In case of butt and corner joints, the reinforcement height R , must not exceed 3 mm for metal thickness of 51 mm and under 5 mm for metal thickness over 51 mm		
iii)	Where the surface of butt joints are required to be flush, the thickness of the thinner base metal or weld metal shall not be reduced by more than 0.8 mm		
iv)	Under cut depth shall not exceed 0.8 mm or 7 percent of the base metal thickness		
v)	Welds shall be free from overlap		

65.1.3 Radiography Procedure and Acceptability**a) Radiographic Procedure**

- 1) Radiographic shall be made by either X-ray or isotope radiation methods.
- 2) The quality level of inspection for radiographs shall be 2.2 T, except that the diameter of the 2T penetrate meter hold need not be less than 1.6 mm for X-ray or 2.4 mm for gamma ray radiographs.
- 3) Radiographs shall have a H and D density between 1.5 and 3.5.



WELD SIZE TOLERANCE	
WELD SIZE IN (mm)	WELD SIZE TOLERANCE IN (mm)
UNDER 10	+1.6 0
10 OR LARGER	+3.18 - 1.6

UNACCEPTABLE BUTT JOINT WELD PROFILES

All dimensions in millimetres.

FIG. 17 WELD PROFILES

- 4) Two or more penetrate meters shall be used for each radiographs on a film 254 or more in length. Only one penetrate meter need be used for radiographs on film less than 254 mm in length.
 - 5) Radiographs shall be made with a single source of radiation approximately centred with respect to the length and width of the area being examined. The distance from radiation source to the film shall not be less than 7 times the maximum thickness of weld being examined, and the rays shall not penetrate the weld at an angle greater than 26.5° from a line perpendicular to the weld surface. The film, during expose, shall be as close as possible to the surface of the weld opposite to the source of radiation.
- b) *Acceptability of Radiographic Welds*
 - 1) Welds subject to radiographic examination shall first be visually examined to check the cracks and welding profiles.
 - 2) The greater dimensions of the porosity or fusion type discontinuity indications that are 1.6 mm or larger shall not exceed the size.
 - 3) Discontinuities meeting requirements of 1 and 2 and having a greatest dimensions of less than 1.6 mm are nevertheless not acceptable if the sum of their greatest dimensions 9.5 mm in any linear 25 mm of weld.
 - 4) The limitations for 38 mm groove weld effective throat shall apply to all welds with larger effective throats.
 - 5) A recommended form for reporting the results of radiographic examination is shown as per 65.1.3 c).

c) *Report of Radiographic Examination of Welds*

Project

Quality requirements — Section No.

Reported to

WELD LOCATION AND IDENTIFICATION SKETCH

Technique source

Film to source

Exposure time

Screens

Film type

(Describe length, width and thickness of all joints radiographed)

Date	Weld Identification	Area	Interpretation		Repairs		Remarks
			Accept	Reject	Accept	Reject	

We, the undersigned, certify that the statements in this record are correct and that the welds were prepared and tested in accordance with the requirements of AWS Specification D-14.1

Radiographer(s)

Manufacturer or contractor

Interpreter

Authorized by

Test date

Date

65.1.4 *Ultrasonic Test, Magnetic Particle and Liquid Penetrant Tests as per IS 4620, IS 5334, IS 3658 respectively.*

- a) Ultrasonic examination of welds,
- b) Ultrasonic testing procedures acceptance criteria,

- c) Magnetic particle examination of welds A,
- d) Liquid penetrant examination of welds, and
- e) The recommended forms for reporting the results of the above tests as shown in the formats below:

REPORT OF MAGNETIC PARTICLE EXAMINATION OF WELDS

Project

Quality requirements — Section No.

Reported to

WELD LOCATION AND IDENTIFICATION SKETCH

Date	Weld Identification	Area	Interpretation		Repairs		Remarks
			Accept	Reject	Accept	Reject	

We, the undersigned, certify that the statements in this record are correct and that the welds were prepared and tested in accordance with the requirements of AWS Specification D-14.1

Inspector.....

Manufacturer or contractor

Test date

Authorized by

Date

Method of Inspection :

1. Dry 2. Wet 3. Residual 4. Continuous 5. A.c. 6. D.c. 7. Half-wave

DYE PENETRANT INSPECTION REPORT

Customer Date.....
 Order No. Material
 Drawing No. Specification

Places	Description	Comments

Soak time

The above parts have been carefully tested with dye penetrant. This inspection is limited to defects of the type which can normally be located with the dye penetrant inspection method.

65.1.5 Repair and Correction of Discontinuities

- a) *Overlap or excessive convexity* — Remove excess weld metal;
- b) *Excessive concavity of weld or crater and under size welds* — Prepare surfaces and deposit additional weld metal. All slag shall be removed and the adjacent base metal shall be cleaned before additional welding;
- c) *Cracks in weld or base metal* — Determine the extent of the cracks by dye penetrant magnetic particle inspection or other suitable means. Remove the crack and adjacent sound metal for a 51 mm length beyond each end of the crack and then reweld; and
- d) *Under cutting* — Under cutting may be repaired by grinding and blending or by welding. Grinding should be performed with a pencil type grinder. Blending shall be done with a slope not to exceed 1 in 3 on plates of 13 mm thickness and above, up to 7 percent reduction of base material thickness is permitted. When undercut is to be repaired by welding, prepare the surfaces and then deposit additional weld metal.

65.1.6 Base Material Repairs

- a) *Defects in edges of plate* — If a defect is found in a plate edge that excess the limits, shall be removed and repaired;
- b) *Arc strikes and temporary attachment* — Areas : Arc strikes or severed temporary welds in critical locations, must be ground smooth to ensure that no abrupt change in section exists;
- c) *Removal of defective areas* — The removal of weld metal or portions of the base metal may be done by machining, grinding, chipping, oxygen gouging or air carbon arc gouging. It shall be done in such a manner that the remaining weld metal or base metal is not nicked or undercut.
 Unacceptable portions of the weld shall be removed without substantial removal of the base metal. Additional weld metal, to compensate for any deficiency in size, shall be deposited using low hydrogen electrodes;
- d) *Distortion and camber* — Members distorted by welding shall be straightened by mechanical means or by carefully supervised application of a limited amount of localized heat. The temperature

of heated areas, as measured by approved methods shall be limited to that imposed by the materials exposed to the heat, but it shall not exceed 590°C for quenched and tempered steel nor 890°C for other steel; and

- e) *Correction of improperly fitted and welded members* — If a weld is found to be unacceptable after additional work has rendered it inaccessible, or new condition make correction of the unacceptable weld dangerous or ineffectual, or original conditions shall be resorted by removing welds or both, before the corrections are made.

66 TESTING

66.1 Preliminary Tests

The preliminary tests shall be done before the hoist block is reeved. Test the various methods as follows. Close the runway, disconnect the switch, the main crane disconnect switch, and the individual motor and accessory switches in that order.

66.1.1 Hoist (Main Hoist and Auxiliary Hoist)

- a) Place master switch in 1st point 'hoist' position;
- b) Observe the contactor for proper sequence and direction of hoist drum rotation. If operating correctly the speed may be gradually increased;
- c) If hoist contactor and rotation is not correct, shut off power, reverse two leads on the main line collectors or on the hoist motion (whichever is incorrect), to obtain the correct phasing. Restore power the repeat step (a) and (b);
- d) After checking hoisting, return master switch to neutral position and observe braking action, readjust if needed;
- e) Place master switch in 'lower' 1st point and observe, if correct motion and contactor sequence occurs;
- f) Reset hoist timers, if needed;
- g) Speed points shall be for accelerating only and shall not be used for running any distance. Maximum time for acceleration is 15 s, unless special equipment is provided. If held any longer, resistor damage may occur; and
- h) The above steps (a) to (g) shall be repeated for auxiliary hoist same as main hoist.

66.1.2 Cross Travel Motion

- a) Place master switch in I point 'trolley travel' position;
- b) Observe contactor sequence and direction of travel through full range of master reverse phasing, if necessary;

- c) Allow trolley to move entire length of bridge span, are fully watching alignment of trolley collector pole and bridge conductors and also watching for any interference with building and building equipment. Do not run trolley into end stops;
- d) Adjust end limit switch trip;
- e) Reverse master switch and repeat (a) to (d); and
- f) Reset trolley timers, if needed.

66.1.3 Bridge Motion (Long Travel)

- a) Place master switch in 1st point 'bridge travel' position;
- b) Observe contactor sequence and direction of travel through full range of master switch. Reverse phasing, if necessary;
- c) Allow crane to move entire length of travel, carefully watching alignment of bridge collector pole and bridge conductors and also watching for any interference with building and building equipment. Do not run crane into end stops;
- d) Adjust end limit switch trip;
- e) Reverse master switch and repeat (a) to (d); and
- f) Reset bridge timers, if needed.

NOTE — At manufacturer premises idle run of bridge motion drive can be tested with no load.

66.1.4 Check all Accessories for Proper Function

66.2 No-Load Test

66.2.1 After reeving the hoist, the operation of the hoist limit switches are to be tested as follows:

- a) Raise empty blocks to within about 500 mm of its upper position and stop;
- b) Raise the empty block at the lowest control speed until the limit switch trips and stops the hoisting motion. During this operation watch for proper alignment between load block and limit switch trip;
- c) Check that block stops at correct height as shown on drawings. Adjust limit switch, if necessary;
- d) Lower the block suitably to reset the upper limit switch;
- e) Raise block at about half speed;
- f) Check for adequate clearance between block and trolley frame (or upper sheaves);
- g) Repeat points (d), (e) and (f) with block being raised at full speed;
- h) Check for one spare groove available on drum in top most position; and
- j) Ensure that at least two rope turns are still wound on drum before rope clamp to avoid chances of load coming on rope clamp.

66.2.2 If crane is equipped with a lower limit switch proceed as follows:

- a) Lower the empty block until one wrap rope remains on each end of the drum; and
- b) Set lower limit switch to trip at this point (or any higher elevation).

66.2.3 Never lower block beyond the point at which one wrap remains at each end of the drum.

66.3 Load Test

After the no-load running test has been completed, the crane should be tested with loads in the following manner:

66.3.1 Raise a load equal to about 50 percent of the rated load not higher than required to clear its supports and stop adjust brake, if necessary. Raise load about 1 m above its supports and stop. Lower the load about 300 mm and stop. Check drift of load during stopping. If load drifts, brakes should be corrected. Repeat this operation until proper adjustment of brakes is obtained. Lower load carefully back to its supports.

66.3.2 Load the hoist motion with 100 percent of rated capacity and follow the same procedure as mentioned in **66.3.1**.

- a) Hoist the load high enough to clear all obstructions but not higher than necessary. Move trolley across the entire span of bridge. Transport the test load by means of the bridge for full length of the runway in one direction with the trolley at the extreme right hand end of the crane, and in the other direction with the trolley at the extreme left hand end of the crane.
- b) The deflection test shall be carried out with the safe working load at rest in air and with the trolley in a central position. The measurement shall not be taken on the first application of the load. The datum line for measuring the deflection should be obtained by placing the trolley without live load on the extreme end of the crane span with smaller hook approach (*see* IS 807 for allowable deflection limit).
- c) Measure the 'no-load' and 'full load' current of the motor and verify whether it is as per the recommendations of motor manufacturers. Check the resistors in the circuit whether any over-heating of the element occurs.
- d) If separate creep speed control is provided it should be run for check-out over a distance of about 500 mm.
- e) Check overload relays (if any) for proper function.

66.4 The actual hoisting and travelling speed shall be within ± 10 percent of specified speed. In shop test long travel speed may be verified in idle condition by revolution of wheels.

66.5 Overload Tests

66.5.1 After full load test but before putting crane into service, crane shall (with overload relays appropriately set) be tested to lift and sustain a minimum test load of 125 percent of the working load, when the load is located at the center of the span.

66.5.2 During the overload test each motion in turn shall be maneuvered in both directions and the crane shall sustain the load under the full control. The specified speeds need not be attained but the crane shall show itself capable of dealing with the overload without difficulty.

66.5.3 Duration of overload test should be kept as minimum as possible.

NOTES:

1 Test load and necessary lifting tackles shall be provided by the purchaser or as per contract.

2 If the load test is to be carried out at crane manufacturer's premises the same should be agreed by both manufacturer and purchaser. The limitation of load test should be discussed and finalized during finalization of order.

67 CRANE-RECOMMENDED/PREFERRED PARAMETERS

67.1 General

To aid economic manufacture it is recommended that the crane parameters given in **67.2** to **67.4** be selected from a progression based upon the preferred number series.

67.2 Preferred Lifting Capacities

Preferred series R10 shall be used for capacities up to and including 125 tonne and R20 for capacities above 125 tonne. The preferred lifting capacities (in tonne) are as follows:

1.0	3.2	10	32	100	225	400
1.25	4.0	12.5	40	125	250	450
1.6	5.0	16	50	140	280	500
2.0	6.3	20	63	160	320	560
2.5	8.0	25	80	200	360	etc.

67.3 Preferred Lifting Height

Preferred series R5 shall be used for lifting heights up to and including 16 m and R10 for heights above

16 m. The preferred lifting heights (in metres) are as follows:

2.5	10	25	50
4.0	16	32	63
6.3	20	40	etc

67.4 Preferred Speed of Operation (Full Speeds)

Preferred series R5 and R10 shall be used for full speed *of* operation respectively. The preferred speeds *of* operation (in m/ min) are as follows:

0.63	1.6	4.0	10	25	63	160
0.8	2.0	5.0	12.5	32	80	200
1.0	2.5	6.3	16	40	100	-
1.25	3.2	8.0	20	50	125	-

ANNEX A

(Clause 1.1)

A-1 LIST OF THE STEEL PLANT CRANES AND SPECIAL SERVICES MACHINES COVERED BY THE CODE

This specification applies to the following types of cranes and special service machines (the list is not exhaustive):

- a) Coke ovens charging;
- b) Coke ovens drawing (coke pushers);
- c) Blast furnace cast house;
- d) Pig machine;
- e) Ladle cranes used in the charging and/or tapping of hot metal mixer vessels, bessemer converters of LD vessels, open hearth and electric furnaces, etc.;
- f) All cranes and machines (either floor mounted or running on over-head gantries) used to cold charge open hearth or electric furnace, etc, or used to charge and draw all types of reheating furnaces;
- g) Bucket handling cranes at various raw and scrap material stock yards, trolley cranes and bridges handling, coal, ore, limestone, etc, or by-product or waste materials, such as slag, cinder and mill scale;
- h) Magnet cranes used for skull cracking, and for handling and preparing steel scrap;
- j) Magnet and cradle cranes for handling semi-finished steel (such as, slabs, blooms and billets) and for stocking and shipping finished products (such as, structurals, rails, plates and sheets) in the various mills and departments.;
- k) Ingot and ingot mould handling cranes at stripper yards, ingot stock yards and soaking pit buildings, etc;
- m) Mill building cranes for changing stands and rolls in the various mills; and
- n) Cranes and repair trolleys on fixed high level gantries for the servicing and repair of furnaces or of ladle cranes or stripper cranes, etc.

ANNEX B

(Clause 1.3)

B-1 TYPICAL CLASSIFICATION OF CRANE MECHANISM

This Annex shows the range of crane mechanism classifications normally associated with particular types of crane. It should not be considered as substitute for the process of determining classification.

B-2 OVERHEAD TRAVELLING INDUSTRIAL TYPE CRANES (O.T.C)

Type of Crane	Motion	Mechanism Classification			
		Class of Utilization	State of Loading	Group of Mechanism	
Power station O.T.C	Hoist and aux. hoist	T3	L1 L2	M3	
	Cross traverse	T3	L1 L2	M3	
	Long travel	T3	L2	M3	
O.T.C for assembly and dismantling machinery	Hoist and aux. hoist	T3	L1 L2	M3	
	Cross traverse	T3	L1 L2	M3	
	Long travel	T3	L2	M3	
O.T.C stores	Hoist and aux. hoist	T4 T5	L1 L2	M3 M5	
	Cross traverse	T4 T5	L1 L2	M3 M5	
	Long travel	T4	L2 L3	M4 M5	
O.T.C workshop	Hoist and aux. hoist	T4 T5	L1 L2	M3 M5	
	Cross traverse	T4 T5	L1 L2	M3 M5	
	Long travel	T4	L2 L3	M4 M5	
O.T.C grabbing	Hoist	T5 T7	L3	M6 M8	
	Closing motion	T5 T7	L3	M6 M8	
	Cross traverse	T5 T7	L3	M6 M8	
	Long travel	T5 T6	L3	M6 M7	
O.T.C. scrapyard or magnet	Hoist and aux. hoist	T5 T6	L3	M6 M7	
	Cross traverse	T5 T6	L3	M6 M7	
	Long travel	T5	L3	M6	
O.T.C. with magnet for transporting plates and like	Hoist	T5 T6	L3	M6 M7	
	Cross traverse	T5 T6	L3	M6 M7	
	Long travel	T5	L3	M6	
O.T.C. for containers	Hoist	T5 T7	L2 L3	M5 M8	
	Cross traverse	T5 T7	L3	M5 M8	
	Long travel	T5 T7	L2 L3	M5 M8	
O.T.C. foundry ladle (for the selection of hoist rope for dangerous handling operation, see 8.5.)	Hoist	T5 T6	L2 L3	M5 M7	
	Cross traverse	T5 T6	L2 L3	M5 M7	
	Long travel	T5	L3	M6	
O.T.C. process cranes	Hoist	T6 T7	L2 L3	M6 M8	
	Cross traverse	T5	L3	M6	
	Long travel	T6	L3	M7	

B-3 OVERHEAD TRAVELLING STEEL WORKS CRANES AND TRANSPORTERS

Type of Crane	Motion	Mechanism Classification			
		Class of Utilization		Class of Loading	Class of Mechanism
Ladle crane (for the selection of hoist rope for dangerous handling operation, <i>see</i> 8.5.)	Hoist and aux. hoist	T6	T7	L4	M8
	Cross traverse	T5	T6	L4	M7 M8
	Aux. traverse	T5	T6	L3	M6 M7
	Long travel	T6	T7	L4	M8
Pig/scrap, breaking crane	Hoist	T5	T6	L4	M7 M8
	Cross traverse	T5	T6	L4	M7 M8
	Long travel	T5		L3	M6
Stripper, vertical ingot charger and soaking pit mould handling crane	Hoist	T7	T8	L3	M8
	Aux. hoist	T5	T6	L2	M5 M6
	Cross traverse	T6	T8	L4	M8
	Long travel	T6	T7	L4	M8
	Slewing	T6	T7	L3	M7 M8
	Closing tong motion	T6	T7	L4	M8
Furnace charging crane	Hoist and aux. hoist	T7	T8	L3	M8
	Cross traverse	T7	T8	L3	M8
	Aux. traverse	T5	T6	L2	M5 M6
	Long travel	T7	T8	L3	M8
Forging crane	Hoist	T6	T8	L3	M7 M8
	Cross traverse	T5	T6	L3	M6 M7
	Long travel	T6	T8	L3	M7 M8
In line process crane	Hoist	T7		L3	M8
	Cross traverse	T5		L3	M6
	Long travel	T6		L3	M7
Off line process crane	Hoist	T6	T7	L2	M6 M7
	Cross traverse	T5		L2	M5
	Long travel	T6		L2	M6
Heavy mill service	Hoist	T5	T6	L2	M5 M6
	Aux. hoist	T4		L2	M4
	Cross traverse	T5		L2	M5
	Long travel	T5	T6	L2	M5 M6
Service and maintenance crane	Hoist and aux. hoist	T4	T5	L1-L2	M3 M5
	Cross traverse	T4	T5	L1-L2	M3 M5
	Long travel	T4		L2-L3	M4 M5
Transporter: medium duty general use	Hoist	T5		L2-L3	M5 M6
	Cross traverse	T5		L2-L3	M5 M6
	Long travel	T5		L2-L3	M5 M6
	Boom hoist	T4		L1	M3

B-4 OVERHEAD TRAVELLING STEEL WORKS CRANES AND TRANSPORTERS

Type of Crane	Motion	Mechanism Classification					
		Class of Utilization		Class of Loading		Class of Mechanism	
Transporter; heavy duty intermittent grabbing and magnet work	Hoist (hold and close)	T6	T7	L3	L4	M7	M8
	Cross traverse	T6	T7	L3	L4	M7	M8
	Long travel	T6		L2	L3	M6	M7
	Boom hoist	T4		L1		M3	
Transporter; extra heavy duty continuous grabbing and magnet work	Hoist (hold and close)	T8	T9	L4		M8	
	Cross traverse	T7	T8	L4		M8	
	Long travel	T7		L3		M8	
	Boom hoist	T4		L1		M3	

ANNEX C

(Clause 2)

LIST OF REFERED INDIAN STANDARDS

<i>IS No.</i>	<i>Title</i>	<i>IS No.</i>	<i>Title</i>
694 : 2010	Polyvinyl chloride insulated unsheathed and sheathed cables/ cords with rigid and flexible conductor for rated voltages up to including 450/750 V (<i>fourth revision</i>)	3658 : 1999	Code of practice for liquid penetrant flaw detection
		3658 : 1999	Code of practice for liquid penetrant flaw detection (<i>second revision</i>)
807 : 2006	Code of practice for design, manufacture, erection and testing (structural portion) of cranes and holes (<i>second revision</i>)	4260 : 2004	Recommended practice for ultrasonic testing of butt welds in ferritic steel (<i>third revision</i>)
875 (Part 3) : 2015	Design loads (other than earthquake) for buildings and structures — Code of practice: Part 3 Wind loads (<i>third revision</i>)	4460 (Part 1 to 3) : 1995	Gears — Spur and helical gears — Calculation of load capacity
		5334 : 2014	Magnetic particle flaw detection of welds — Code of practice
1030 : 1998	Carbon steel castings for general engineering purposes — Specification (<i>fourth revision</i>)	5749 : 1970	Specification for forged ramshorn hooks
1554	Specification for PVC insulated (heavy duty) electric cables:	7098 (Part 1) : 1988	Crosslinked polyethylene insulated pvc sheathed cables: Part 1 For working voltages up to and including 1100 V (<i>second revision</i>)
(Part 1) : 1988	For working voltages up to and including 1 100 V (<i>third revision</i>)	7504 : 1995	Gears — Cylindrical gears — Accuracies — Method of inspection (<i>first revision</i>)
(Part 2) : 1988	For working voltages from 3.3 kV up to and including 11 kV (<i>second revision</i>)	9968	Specification for elastomers insulated cables:
1570 (Part 1) : 1978	Schedules for wrought steels: Part 1 Steels specified by tensile and/or yield properties	(Part 1) : 1988	For working voltages up to and including 1 100 V (<i>first revision</i>)
1570 (Part 2) : 1979	Schedules for wrought steels: Part 2 Carbon steels (unalloyed steels)	(Part 2) : 2002	For working voltages from 3.3 kV up to and including 33 kV (<i>first revision</i>)
2048 : 1983	Specification of parallel keys and key-ways (<i>second revision</i>)	10118	Code of practice for selection, installation and maintenance of switchgear and control gear:
2062 : 2011	Hot rolled medium and high tensile structural steel	(Part 2) : 1982	Selection
2266 : 2002	Steel wire ropes for general engineering purpose — Specification (<i>fourth revision</i>)	(Part 3) : 1982	Installation
		(Part 4) : 1982	Maintenance
2553 (Part 1) : 1990	Safety glass: Part 1 General purpose (<i>third revision</i>)	(Part 1) : 2018	General (<i>first revision</i>)
3043 : 2018	Code of practice for earthing (<i>second revision</i>)	12615 : 2018	Line operated three phase a.c. motors (IE Code) 'efficiency Classes and Performance Specification' (<i>third revision</i>)
3443 : 1980	Specifications for crane rail sections (<i>first revision</i>)	13367 (Part 1) : 1992	Safe use of cranes — Code of practice: Part 1 General

<i>IS No.</i>	<i>Title</i>	<i>IS No.</i>	<i>Title</i>
13743 (Part 1) : 2015	Cranes — Vocabulary: Part 1 General	IS/IEC 60947-4-1 : 2012	Low-voltage switchgear and controlgear: Part 4 Contactors and motor-starters, Section 1 Electromechanical contactors and motor-starters (<i>first revision</i>)
13834 (Part 1) : 2018	Cranes — Classification: Part 1 General (<i>first revision</i>)	IS/IEC 60947-2 : 2016	Low-voltage switchgear and control gear: Part 2 Circuit breakers (<i>first revision</i>)
15560 : 2005	Point hooks with shank up to 160 tonne — Specification	AWS 14.1 : 1997	Specification for welding of industrial and mill cranes and other material
16003 : 2012	Specification and qualification of welding procedures for metallic materials — General rules	DIN 15407-1 : 1970	Lifting hooks; laminated hooks with a point for spigot ladles, assembly, principal dimensions
16504 (Part 1) : 2019	Safety of machinery — Electrical equipment of machines: Part 1 General requirements (<i>first revision</i>)	DIN 15400 : 1990	Lifting hooks; materials, mechanical properties, lifting capacity and stresses
16504(Part 32) : 2017	Safety of machinery — Electrical equipment of machines: Part 32 Requirements for hoisting machines		
16819 : 2018	Safety of machinery — General principles for design — Risk assessment and risk reduction		

ANNEX D

(Clause 4.1)

INFORMATION TO BE SUPPLIED BY THE BUYER

D-1 GENERAL

D-1.1 Number of Cranes:

D-1.2 Duty or Class of Crane:

- | | | |
|--|---|--------------|
| <ul style="list-style-type: none"> a) Crane structure b) Main hoist c) Auxiliary hoist d) Cross-traverse e) Long-travel | } | (see IS 807) |
|--|---|--------------|

D-1.3 Safe Working Load, in Tonne:

- | | |
|--|-------|
| a) Main hoist | tonne |
| b) Auxiliary hoist | tonne |
| c) Second auxiliary hoist | tonne |
| d) Stripping and extracting capacity
in case of stripper cranes | tonne |

NOTE — In case of magnet and grabbing cranes, the specification and physical condition of the material to be handled shall be given.

D-1.4 Gantry or Track Rail (see Fig. 18)

- | | |
|-------------------------------|-----------|
| a) Size and weight | tonne; or |
| b) Width of head (<i>B</i>) | mm. |

D-1.5 Ambient Conditions

- a) Ambient temperature, in °C (*Max*); or
- b) Relative humidity (*Max*).

D-1.6 Number of tender documents, including drawings and relevant technical literature required

D-1.6.1 Any Requirement For

- a) Detailed drawings for approval

D-2 CRANE PERFORMANCE

D-2.1 Operating Speeds (Loaded), Not Less Than

- a) Main hoist..... m/ min; and
- b) First auxiliary hoist.....m/min.

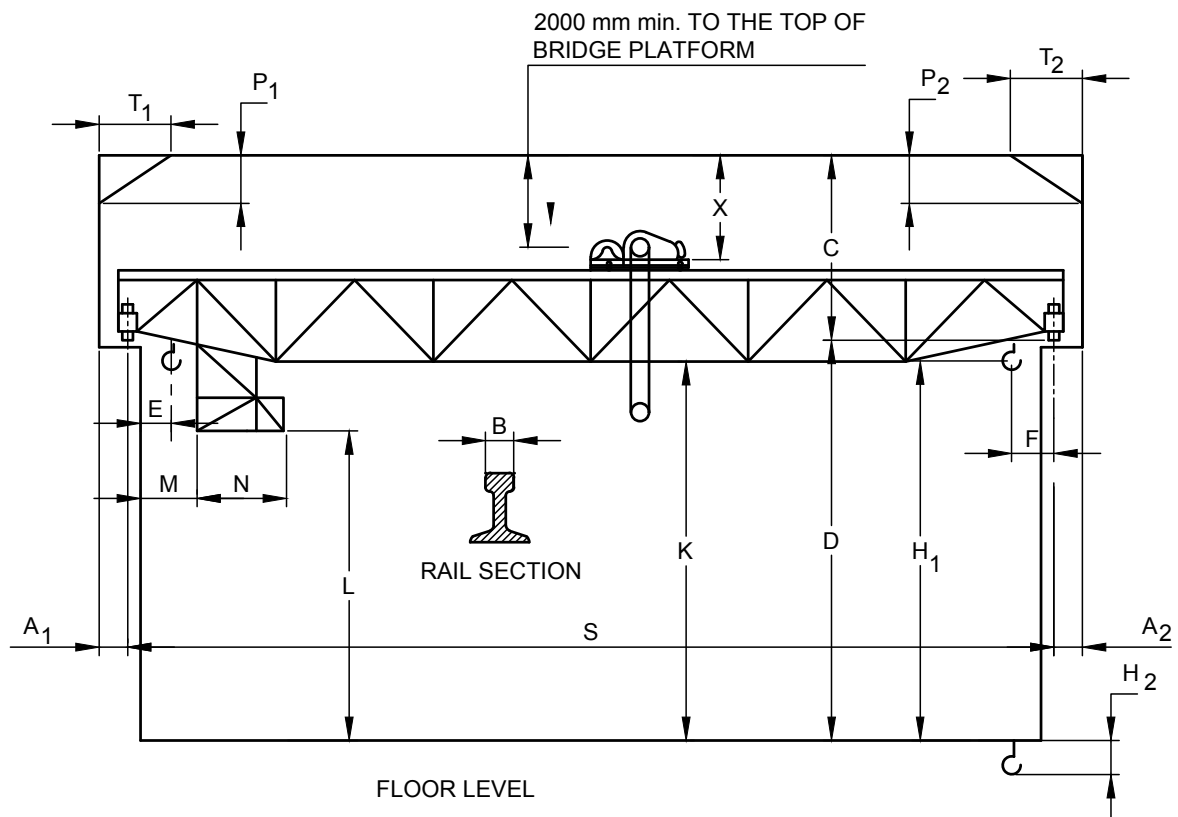


FIG. 18 OVERHEAD TRAVELLING CRANE

ANNEX E

(Clause 4.2)

INFORMATION TO BE FURNISHED BY THE MANUFACTURERS (SELLER)

E-1 GENERAL

E-1.1 Number of Cranes

E-1.2 Duty or Class of Crane

E-1.3 Span of the Crane, in mm

E-1.4 Safe Working Load, in Tonne

- a) Main hoist m/min
- b) Auxiliary hoist m/min

E-1.5 Crane Speed

- a) Main hoist m/min
- b) First auxiliary hoist m/min
- c) Second auxiliary hoist m/min
- d) Cross-traverse (main). m/min
- e) Cross-traverse (Auxiliary) m/min
- f) Long travel m/min

E-2 CRANE AND COMPONENTS WEIGHT

- a) Total weight of the crane tonne
- b) Total weight tonne
- c) Girders weight tonne
- d) End carriage weight tonne
- e) Wheel loads:
 - 1) Maximum wheel load tonne
 - 2) Minimum wheel load tonne
 - 3) Mean wheel load tonne

E-3 STRUCTURAL DETAILS (see FIG. 18)

E-3.1 Distance between centre lines of gantry or track rails (S) metres (span)

NOTE — It is recommended that the span of the track shall not vary by more than ± 12 mm. When the track span does not satisfy this requirement the maximum and minimum span for which the crane has to be designed shall be specified by the purchaser.

E-3.2 Side Clearance

- a) Distance from centres of gantry or track rails to nearest side:
 - 1) (A1) metre
 - I. (A2) metre
- b) Distance from top of gantry rail to:
 - 1) Lowest overhead obstruction (C) metre
 - 2) Floor level (D) metre

E-3.3 End Clearances:

- (P_1) metre
- (P_2) metre
- (T_1) metre
- (T_2) metre
- (R_1) metre
- (R_2) metre

E-3.4 Vertical clearance to underside of bridge:

- (K) metre

E-3.5 Operator's Cabin:

- a) Clearance height to under side of cabin (L) metre
- b) Length of cabin (N) metre
- c) Distance from back of cab into nearest gantry rail (for fixed cabin) (M) metre

E-3.6 Lift of hook above floor level:

- a) Main hook (H1) metre
- b) First auxiliary hook metre
- c) Second auxiliary hook metre

E-3.7 Drop of hook below floor level:

- a) Main hook (H2) metre
- b) First auxiliary hook metre
- c) Second auxiliary hook metre

E-3.8 Nearest position of hook to centre of gantry rail:

- a) Main hoist:
 - 1) Cabin end (E) metre
 - 2) Cabin end (F) metre
- b) First auxiliary hoist:
 - 1) Cabin end (E) metre
 - 2) Cabin end (F) metre
- c) Second auxiliary hoist:
 - 1) Cabin end (E) metre
 - 2) Cabin end (F) metre

E-3.9 Any other site restrictions

E-4 OPERATOR'S CABIN DETAILS

E-4.1 Type of Cabin

- a) Fixed or moving
- b) Location on bridge, if fixed

E-4.2 Open or Closed Type

E-4.3 Any Requirement for:

- a) Steel plate of thicknesses other than 3 '15 mm
- b) Insulated cabin walls
- c) Insulated floors
- d) Window opening on hinges.. .. .
- e) Dispensing with platform outside cabin door
- f) An extraction fan (door should open inwards where platform is not provided) .. .
- g) A circulating fan.....
- h) Air-conditioning for totally enclosed cabin
- j) Fire extinguishers

E-5 MECHANICAL DETAILS**E-5.1 General**

- a) Type of long travel drive
- b) Make and type of flexible couplings.....
- c) Type of any overload slip device (fluid coupling, plate-clutch, or cone clutch)

E-5.2 Type of Hooks

- a) Main hoist
- b) First auxiliary
- c) Second auxiliary.....

E-5.3 Any Requirement For

- a) A lifting beam on outdoor cranes
- b) Built in jacks on end carriages
- c) Built in jacks on crabs
- d) Special rail wheel tyres
- e) Special gearing arrangements or details
- f) Bearing other than ball or roller type
- g) Bearings having full ring cartridge housings

- h) Centralized lubricating system
- j) Locking device on swiveling hooks
- k) Closing fingers on the hooks

E-6 ELECTRICAL DETAILS**E-6.1 Electric Supply**

- a) *d.c. supply*
Volts No. of wires
Supply (rectifiers or not)
- b) *a.c. supply*
Volts No. of wires
Frequency No. of phases
Neutral (earthed or dot).....

E-6.2 Braking

Any requirements for:

- a) Electromechanical shunt brake(s) on hoist motion(s).....
- b) Emergency brake(s) on hoist motion(s) of moving cabin cranes (electromechanical shunt, mechanical or hydraulic).....
- c) Emergency electro-mechanical shunt brake(s) on:
 - 1) Hoist motions of fixed cabin cranes.....
 - 2) Cross-travel motion(s) of moving cabin cranes.....
 - 3) the Long travel motion of fixed cabin cranes.....
- d) Emergency lowering of load by hand operation of brakes.....
- e) A mechanical drag brake on crab.....
- f) Brake magnet coils to be fed from a.c.
- g) Alternative brake magnet coil ratings.....
- h) Additional brakes for other motions or purposes.....

E-6.3 Motors

- a) Manufacturer of main motors :
- b) Class of insulation of main motors.....
- c) d.c. mill motor details (if not selected from any standard specification)

Motion	Motor frame	kW	STR* or IDF	Voltage	Class of insulation	Temperature rise	Rev/Min		
							Series	Compound	Shunt

* STR = short time rating.
IDF= intermittent duty factor

- d) Any special motor lead or terminal requirements

E-6.4 Main Control Gear

E-6.4.1 *Type of Control Panels* (open or separate closed units).....

E-6.4.2 *Short Time Rating or Duty Cycle Ratings of Resistors:*

- a) Hoist motions
b) Cross-travel motions
c) Long-travel motions

E-6.4.3 *Scheme of Protection for Main Control Circuits:*

- a) Protection of each motion, or.....
b) Tripping out crane supply if overload on any motion

E-6.4.4 *Any Requirement for:*

- a) A special control system, or a control system other than automatic control of acceleration for any motion (for example, drum or mechanically operated contactor controller)
b) Emergency rheostatic braking on travel motions:
1) cross-travel
2) long-travel
c) an electrically operated main circuit-breaker
d) special clearances of creepages

E-6.5 Auxiliary Switching

E-6.5.1 *Any Requirement for:*

- a) special position of:
1) main isolating switch
2) additional main isolating switch
b) HBC fuse protection for main isolators
c) auxiliary contacts on the main isolating switch to operate the crane warning lights
d) an isolating switch on the main circuit of each motion
e) an isolating switch on the control circuit of each motion
f) special creeping button to by-pass lower hoist limit switches
g) track switches (number, details and whether to operate a warning signal, or trip the main circuit-breaker)
h) proximity warning devices (number, location and duty)

E-6.6 Disposition and Housing of Electrical Equipment

E-6.6.1 *Location of Electrical Equipment Compartment for*

- a) Fixed cabin cranes (below or above the bridge platform, or above the cab)
.....
.....
b) Moving cabin cranes (above the bridge platform level, or above the cab), ...
.....

E-6.7 Long-Travel System

E-6.7.1 Provision of long-travel collectors (purchaser or manufacturer)

E-6.7.2 Details of mountings on bridge structure for long-travel collectors, if these are to be provided by the purchaser.....

E-6.7.3 Details of long-travel conductors, if long-travel collectors are to be provided by the manufacturer.....

E-6.7.4 Type of long-travel collectors if these are to be provided by the manufacturer.....

E-6.8 Cross-travel System

E-6.8.1 Any requirement for flexible cable type of cross-travel system.....

E-6.8.2 Type of cross-travel conductors (rolled steel section or wires)

E-6.8.3 Maximum current density for cross-travel conductors (if higher than that recommended in *this* specification).....

E-6.8.4 Provision of cross-travel collectors (purchaser or manufacturer)

E-6.8.5 Details of mountings on the trolley for cross-travel collectors, if these are to be provided by the purchaser

E-6.8.6 Type of cross-travel collectors, if these are to be provided by the manufacturer

E-6.9 Lifting Magnet and Equipment

E-6.9.1 If lifting magnets and magnet control and protective gear are to be provided:

- a) Type and size of magnets... ..
.....
b) Type of magnet control (direct-on-line or potentiometer)... ..
c) Type of master controller for direct-on-line control (hand or foot operated).....
.....
d) Type of potentiometer control (master drum or mechanically operated contactor controller).

E-6.9.2 Any requirement for:

- a) provision for future fitting of a lifting magnet (number of extra cross-travel conductors)
- b) rubber hose protection of magnet lead.....
- c) special type of magnet coupling

E-6.10 Crane Illumination and Warning Lights

Any requirement for:

- a) lighting of the bridge walkway and the cabin and bridge..... approaches.....
- b) underslung lighting (number, type and location of lamps and lamp fittings)
- c) warning light
- 1) if so, give details of their function

E-6.11 Earthing

Any requirement for:

- a) earthing other than through crane gantry.....
- b) the magnet to be earthed by a connection via the magnet lead, coupling and cable and an extra slip-ring on the magnet cable drum... ..

E-7 PROTECTION OF CRANE STRUCTURE AND MACHINERY**E-7.1 Any Requirement for Special Painting Schemes****E-8 ADDITIONAL REQUIREMENTS****E-8.1 Any Additional Requirements**

ANNEX F

(Clause 7.4.3.2.1)

DETERMINATION OF FATIGUE REFERENCE STRESS

F-1 GENERAL

Clause 7.4.3.2 sets out the procedure for checking the fatigue strength of a mechanical component and outlines the factors which affect its fatigue life. A fatigue reference stress is used in the process of evaluating the fatigue strength. This annex outlines a method of determining the fatigue reference stress for a component detail.

F-2 FATIGUE REFERENCE STRESS, $P_{F,R}$

$$P_{F,R} = C_{F,R} \times F_{ult}$$

Where,

F_{ult} is the minimum ultimate tensile stress of the material

$C_{F,R}$ is a fatigue reference stress factor that depends on the:

- number and characteristics of the stress cycles to which a component is subjected; and
- value of the fatigue limit factor C_{lim} .

F-3 DETERMINATION OF FATIGUE REFERENCE STRESS FACTOR ($C_{F,R}$)

For steels having a minimum ultimate tensile stress not greater than 1 100 N/mm², the value of $C_{F,R}$ is given in Fig. 19(a) for cases of bending stress and in Fig. 19(b) for cases of torsional shear stress. The value of $C_{F,R}$ is determined in accordance with the appropriate number of stress cycles and with the appropriate value of the fatigue limit factor C_{lim} .

Alternatively the factor $C_{F,R}$ can be determined from the following formulae, in which N is the total number of cycles.

$$\begin{aligned} \text{For } N \geq 10^6 \quad C_{F,R} &= C_{lim} \\ \text{For } 10^3 < N < 10^6 \quad C_{F,R} &= A C_{lim}^{(1/3 \log N - 1)} \\ \text{where for bending stresses} \quad A &= 1; \text{ and} \\ \text{for torsional shear stresses} \quad A &= 3^{(1/6 \log N - 1)} \end{aligned}$$

F-4 FATIGUE LIMIT FACTOR (C_{lim})

The fatigue limit factor C_{lim} is the value of $C_{F,R}$ corresponding to the fatigue endurance limit.

$$C_{lim} = \frac{C_1}{C_2 \times C_3 \times K_f}$$

Where,

C_1 = is a stress state factor;

C_2 = is a size factor;

C_3 = is a surface finish factor; and

K_f = is a fatigue notch factor equal to K_{bf} for bending stresses and K_{qf} for torsional shear stresses.

F-5 DETERMINATION OF C_1 , C_2 , C_3 AND K FACTORSF-5.1 Stress Factor C_1

The value of C_1 is given in accordance with the nature of the stress cycles as follows:

Unidirectional bending	$0 < f_{min}/f_{max} < 1$
$C_1 = 0.85$	
Reversing bending	$-1 < f_{min}/f_{max} < 0$
$C_1 = 0.50$	
Unidirectional torsion (shear)	$0 < f_{min}/f_{max} < 1$
$C_1 = 0.50$	
Reversing torsion (shear)	$-1 < f_{min}/f_{max} < 0$
$C_1 = 0.30$	

F-5.2 Size Factor C_2

The size factor is derived from Fig. 20.

F-5.3 Surface Finish Factor C_3

The surface finish factor is dependent on the ultimate tensile stress of the material and the machining process used in manufacture. The value of C_3 is given in Fig. 21 in which R_t is the peak-to-valley height of surface roughness (in μm).

F-5.4 Fatigue Notch Factor K_{bf} , K_{qf}

F-5.4.1 Derivation of Fatigue Notch Factor

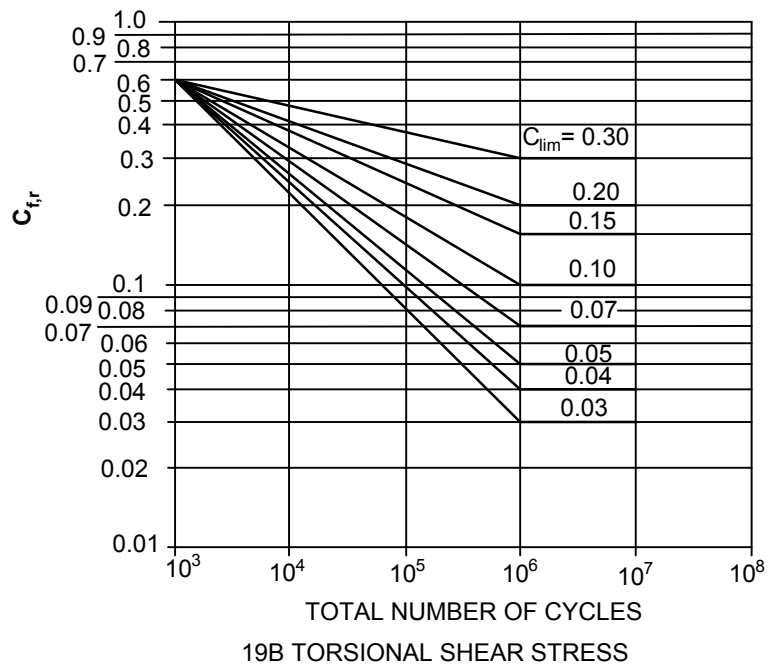
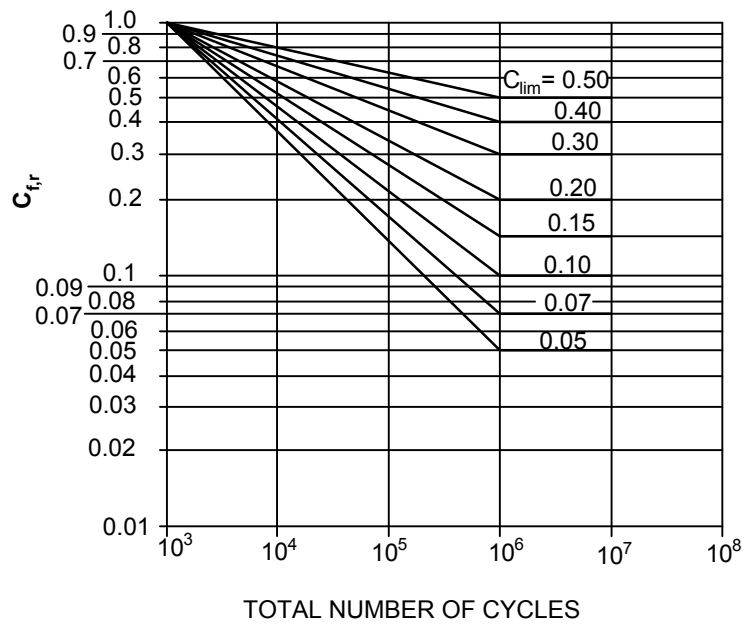
The presence of such details as shoulders, grooves, holes, keyways, threads, etc. results in a modification of the simple stress distribution that would occur in members which have a constant cross section with gradual changes of contour. The resulting localization of high stresses is known as the stress concentration or notch effect and is measured by the stress concentration factor.

The stress concentration factor is defined as:

$$K_b = \frac{f_{b \max}}{f_{b \text{ nom}}} \text{ for bending stress}$$

$$K_q = \frac{f_{q \max}}{f_{q \text{ nom}}} \text{ for torsional shear stress}$$

Where, $f_{b \max}$ and $f_{q \max}$ are the maximum stresses in a component detail and $f_{b \text{ nom}}$ and $f_{q \text{ nom}}$ are the nominal stresses at the corresponding location.

FIG. 19 FATIGUE REFERENCE STRESS FACTOR C_{fr}

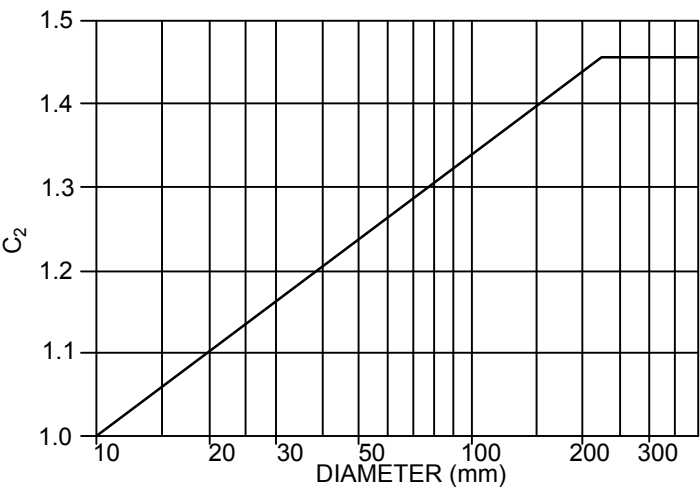


FIG. 20 SIZE FACTOR C_2

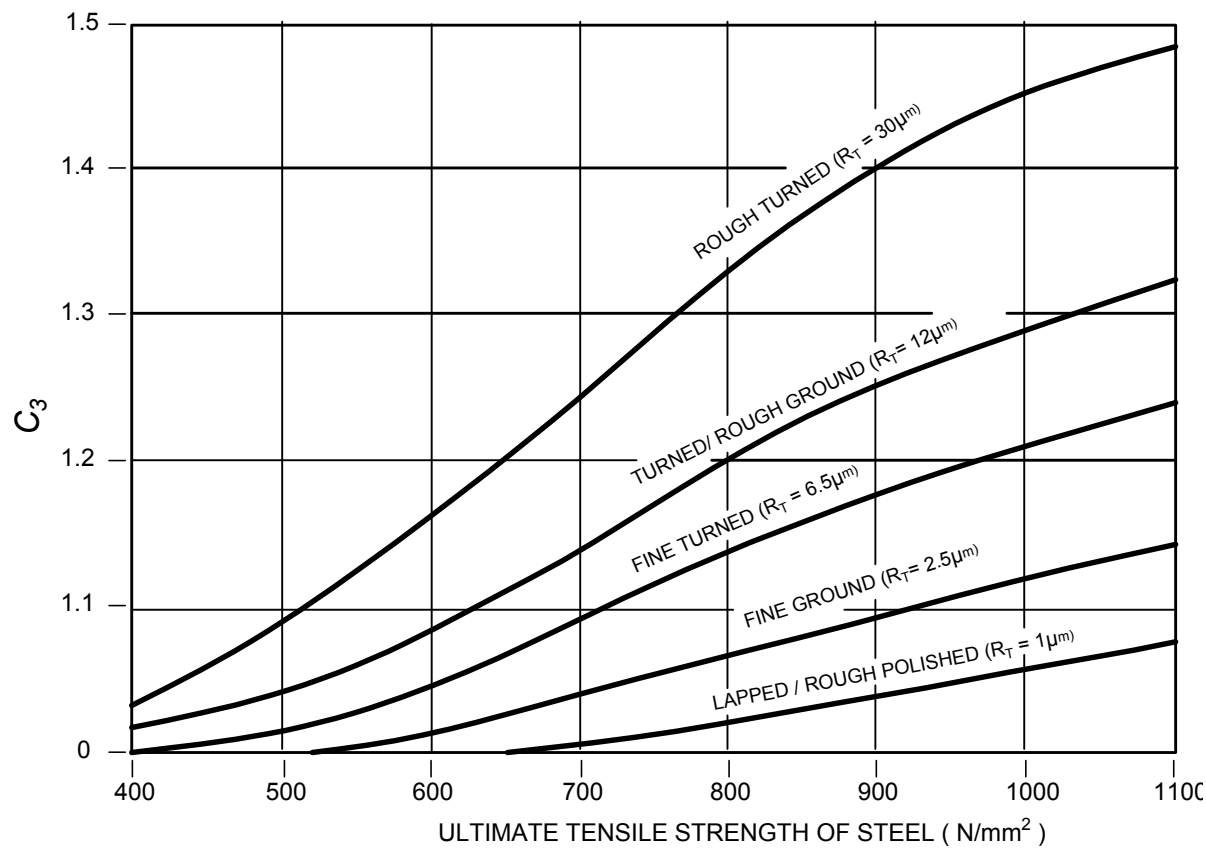


FIG. 21 SURFACE FINISH FACTOR C_3

The effect of a notch on the fatigue strength of a part varies considerably with material and notch geometry and is normally less than would be predicted by the use of the stress concentration factor. The general phenomenon is denoted “notch sensitivity”.

For design purposes the following relations apply:

$$K_{bf} = q (K_b - 1) + 1$$

$$K_{qf} = q (K_q - 1) + 1$$

Where,

q = is the notch sensitivity factor as per Fig. 22;

K_{bf} = is the fatigue notch factor (bending stress); and

K_{qf} = is the fatigue notch factor (torsional shear stress).

F-5.4.2 Stress Concentration Factor

The stress concentration factors K_b and K_q are to be taken from established reference works.

F-5.4.3 Notch Sensitivity Factor

For ductile materials the value of q may be obtained from published reference works or from experimental data.

Where no data exist, then a value of $q = 1.0$ should be used in deriving K_{bf} and K_{qf} .

For brittle materials $q = 1.0$ shall be used in all cases.

F-5.4.4 Stress Concentrations which are Superimposed or in Close Proximity

Treatment of multiple stress concentrations in close proximity is outside of the scope of this annex and where this situation arises reference should be made to established reference works.

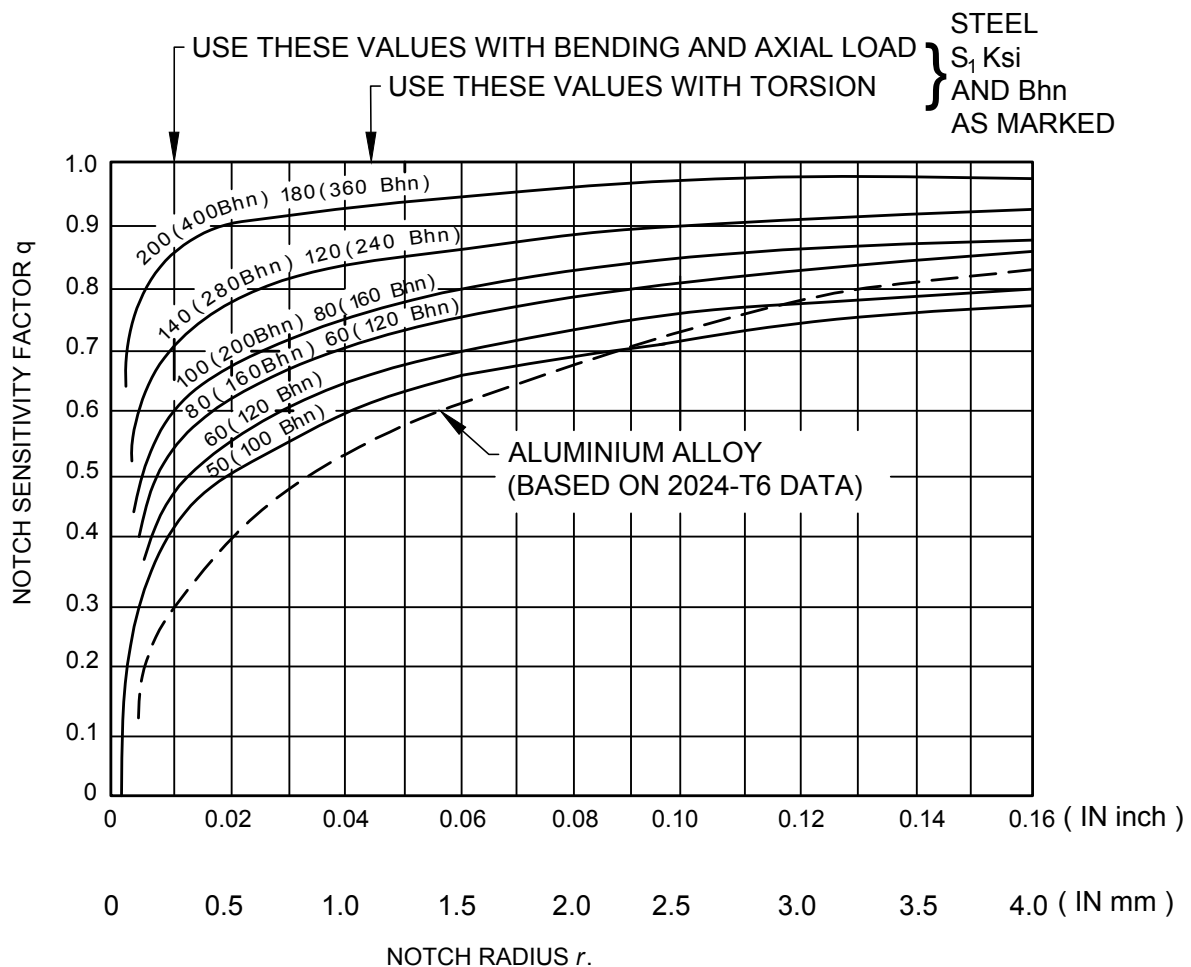


FIG. 22 NOTCH SENSITIVITY CURVES

ANNEX G

(Clause 54.2)

INTERMITTENT RATINGS FOR RESISTORS

G-1 GENERAL

The basis of the rating shall be the ratio of the running time to a total time of 15 min and the resistors are rated to carry the rated full load motor current in any section or sections except where current is restricted to lower value by the amount of resistance in the circuit in which case the resistor shall be rated to carry the current passed with the motor at stand still.

G-2 DEFINITION OF DIFFERENT RATINGS

G-2.1 Two Minute Rating

A resistor having a 2 min rating shall be capable of being left in the circuit for a period not exceeding 30 s on the first section and for a further period of 90 s divided between the remaining sections of the resistor, followed by a period of rest of 13 min. This cycle being repeated until a stable temperature is reached.

G-2.2 Five Minute Rating

A resistor having a 5 min rating shall be capable of being left in circuit for a period not exceeding 2 min on the first section and for a further period of 3 min equally divided between the remaining sections of the resistor, followed by a period of rest of 10 min, this cycle being repeated until a stable temperature is reached.

G-2.3 Ten Minute Rating

A resistor having a 10 min rating shall be capable of being left in circuit for a period not exceeding 4 min on the first section and for a further period of 6 min equally divided between the remaining sections of the resistor, followed by a period of rest of 5 min, this cycle being repeated until a stable temperature is reached.

(Continued from second cover)

The Committee kept in view the manufacturing and trade practices prevailing in the country while formulating the standard.

For the purpose of deciding whether a particular requirements of this standard is complied with the final value, observed or calculated expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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